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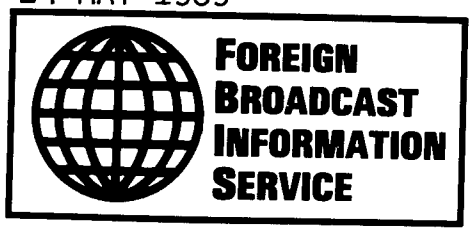

JPRS Report

Science & Technology

China

JPRS-CST-89-011

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SCIENCE & TECHNOLOGY

CHINA

CONTENTS

Nuclear Industry Churning Out Consumer Products

40080115b Beijing KEJI RIBAO in Chinese 11 Jan 89 p 1

[Text] It is estimated that in 1990, China's first nuclear power plant will begin feeding electricity into the power grid. This is a major step for the nuclear industry from a road of exclusively military application of nuclear technology to civilian applications.

In the past few years, China's nuclear industry, in adapting to the requirements of strategic changes, has gone from serving national defense exclusively to emphasis on serving national economic construction. Investment has been cut back by several billion yuan in recent years and a large number of military capital construction projects have been slowed or halted. On this foundation, technology reform is being carried out and much effort is being put into developing consumer products. Altogether, 10 major classifications and over 1,000 products have been developed. Nearly 10 of these products, including an automatic fire alarm, account for individual output values in excess of 10 million yuan. For 1988 alone, the industrial output value of consumer products reached 440 million yuan, accounting for one-third of the gross output value.

Isotopes and radiation technology are important aspects of the peaceful use of nuclear energy. The nuclear industry is striving to develop industrial, agricultural, medical, scientific and other applications for these products. Over 800 types of radioactive isotope products have been developed. Of these, the number which bred through irradiation has reached 194, one-third of the world's irradiation-bred isotope types, occupying a leading position worldwide. Apart from Tibet, nationally there are 1,000 medical and health organizations which use isotope technology in the diagnosis and treatment of over 100 kinds of diseases. The nuclear industry has also transplanted the extraction technology often used in uranium hydrometallurgy for use in the refining of tungsten and the production of medicines. They have applied the separation membrane and nuclear pore membrane technologies to the medicine and food industries, achieving outstanding results.

The nuclear industry stresses the development of the external economy and has put much effort into creating products with foreign exchange earning potential. The natural uranium, metallic tungsten, electromechanical products, and rare earth and diamond products which have been developed have entered the international market, doubling foreign exchange earnings. Production lines for some nonferrous metals, chemicals, lithium batteries and other foreign exchange earning products have been or will soon be completed and commence production. Today, the nuclear industry is making a great effort to develop rare earth, gold, and other products which have the characteristics of the nuclear industry's techniques and technology and can occupy an advantageous position domestically. Additionally, the development and promotion of ion exchange, remote sensing, remote control, vacuum, new materials development, and other non-nuclear advanced technologies has been welcomed by related industries.

With respect to economic returns, 1988 was the best year in the history of the astronautics industry. Basically, simultaneous increases in output value, income from sales and in profit taxes were realized. Consumer product output value accounted for over 79 percent of gross output value with an average monthly rate of increase of 6.5 percent.

While fulfilling the prerequisite of its military product mission, in 1988 the astronautics industry strove to develop consumer products. Output of every major consumer product increased greatly. Motor vehicle output increased 62.9 percent, television output increased 21.8 percent and production of refrigerators jumped 74.8 percent. Earnings from scientific and technological consultation, technology transfer and transfer of technological commodities reached 200 million yuan, creating profits of 65 million yuan. Consumer product exports could reach 30 million U.S. dollars.

The Shanghai Broadcast Equipment Factory is an integrated electronics factory combining R&D with production compatible with both military and civilian applications. During the process of changing over from military to civilian, it first formed concepts of management strategy based on developing products and succeeding through innovation; emphasizing quality and succeeding through excellence; entering markets and succeeding through being first; reforming management and succeeding through honesty. Altogether they developed 4 general categories and 56 consumer products including televisions and television broadcasting equipment. One of these, the Shanghai Brand color television, has received designation as a superior quality product from the original Ministry of Astronautics Industry and the Municipality of Shanghai. While making the "change of course and change of character" shifts in strategy, State managed factory number 811 proposed guiding policies to "accelerate reform, broaden paths of financing, ensure military products, greatly increase consumer products and increase returns." To counter weakness in the design capabilities of the enterprise, they devised the strategic concept of joint development of consumer products through developmental, horizontal economic

technology associations with colleges and universities. The factory's PZ III jet nozzle currently fills a gap in domestic production and accounts for about one-half of domestic production of similar products. The State-managed Fenghua Machine Factory has actively implemented the policy of military and consumer integration and has managed to change course relatively quickly from military work to business enterprise. In order to adapt to high volume production of refrigerators, they took the initiative in promoting new technology and new techniques, they adopted modern management methods, setting up a "materials flow management system" and "capital control and accounting methods." Economic returns have been greatly increased.

Accomplishments of National Defense S&T University Recapped

40080124 Beijing KEJI RIBAO in Chinese 4 Feb 89 p 1

[Excerpt] [Passage omitted] The National Defense Science and Technology University undertook 454 various research tasks in 1988, including high-tech projects, key State projects under the "Seventh Five-Year Plan," all types of science funding projects, projects involving foreign cooperation and independently planned projects. The number of high-tech projects undertaken ranked among the highest in the country. Those key projects listed in the State's "Seventh Five-Year Plan" involved more than 10 fields including artificial intelligence, precision guidance, stealth and counter-stealth technologies, simulator technology and flexible manufacturing systems, far surpassing in number the projects undertaken by this school under the "Sixth Five-Year Plan."

This school completed 207 scientific research tasks in 1988. Sixty-two research accomplishments have passed evaluation, the largest number for any year in the history of this school. Still another group of research accomplishments has passed the pre-acceptance assessment of associated organizations.

Formal utilization of the "Weaver Girl-1" sounding rocket, jointly researched and developed by departments one and five and the Sihai factory, began for the first time last December at the Hainan range. China had for the first time directly acquired middle layer atmospheric data for low latitude regions.

China's first "biped walking robot," successfully developed by Department 3 represents the sophistication of China's robot walking mechanism and has made a contribution to robot research in China.

The high-resolution radar target simulator developed by Department 4 not only can be used for indoor testing and measurement of radars, it can also serve as training simulator material, thereby expanding its application.

SiC fiber-strengthened aluminum pre-cast filaments developed by Department 5 have passed evaluation sponsored by the Ministry of Aeronautics and Astronautics Industry and the Commission of Science, Technology and Industry for National Defense. Internationally, performance has attained

the level of the same type of material from Japan during the period of the mid-80's. This has laid a foundation for China's development of SiC fiber strengthened aluminum composite materials and their application in space travel.

The 100,000,000-operation-per-second Galaxy computer, researched and developed by Department 6 for the Nanxi Computing Center, passed pre-acceptance testing last April after 3 years of arduous struggle, after overcoming destabilizing factors in the computer system and solving a large number of software problems, particularly problems of precision.

The analytical system successfully researched and developed by Department 7 for application to trends in the military cadre structure which is innovative and original in respect to construction of test theories and methods, has passed an evaluation organized by the Commission of Science, Technology and Industry for National Defense. The evaluating specialists felt that the system was functionally complete, broadly applicable, and of an international level.

The successful developments of Department 8, including very high precision manufacturing technology in measurement and control, have allowed the precision of work-piece processing to reach the submicron level. This is China's greatest breakthrough in precision machine processing technology, pushing the precision processing aspect of China's electromechanical integrated technology to a point at or near advanced international levels.

Last year, this school implemented some improvements in the handling of accomplishments. These include specialist evaluation of scientific achievements, pre-acceptance checks, the patenting of products, and other styles of evaluation. Also, detailed rules and regulations were formulated pertaining to the evaluation of accomplishments, and computer aided evaluation was tested. This was done to make assessment fairer and more accurate. The "multi-functional optical design software for non-spherical optical systems" which was successfully developed by Department 2, has passed this school's first line of communications evaluation, with very good results. Both money and manpower were saved and the appraisal comments were more accurate. The results of this project are being applied in Institute 603 of the Ministry of Aeronautics and Astronautics Industry, the Huanan Optical Instruments Factory and other organizations. Striking benefits have been obtained.

Five S&T accomplishments from this school received national-level awards for S&T achievement in 1988. Among these five, were three accomplishments which were awarded the first, second, and third-place national-level awards for progress in S&T, while the other two were awarded the third and fourth place national awards for invention.

Nuclear Industry Non-Destructive Testing Center Established

40080158 Shanghai WUSUN JIANCE [NON-DESTRUCTIVE TESTING] in Chinese Vol 11 No 3, Mar 89 p 90

[Summary] The Nuclear Industry Non-Destructive Testing (NDT) Center established in 1988 in Shanghai will assume the following tasks: (1) management of NDT technology; (2) formulation of development plans and appropriate standards; (3) responsibility for training and qualifications of NDT personnel; (4) conducting of scientific experiments, as well as the development of technical consultation and technical services; and (5) organization of intra-industry, inter-industry, and international technical exchanges and technical cooperation.

On the basis of contracts, the center will provide NFS-series immersion-type and JT-J1-series contact-type ultrasonic focused probes, as well as other focused probes for special needs. The scientific research and development on these searching units was accredited at the ministry level in 1984, and the probes have been in use in flaw-detection systems for some time.

The center has advanced French, West German, and American multifrequency and multifunctional eddy-current flaw detectors and special eddy-current probes suited to the nonferromagnetic heat-exchange tubes used in heat exchangers and condensers. The center also has imported ultrasonic flaw detectors, controlled pulse emission equipment, broadband probes and focused probes for ultrasonic flaw detection in a variety of materials (including austenite, stainless steel, and other coarse-grain materials), equipment, and parts. In addition, the center owns imported 100kV-350kV ray flaw-detection machines and Co60, Ir192, and Cs137 gamma-ray flaw-detection apparatus and pipe crawlers for panoramic ray inspection of circular welding seams in pipelines and other vessels, as well as for other kinds of radio inspection. Finally, the center also has an imported large-scale mobile flaw-detection chamber, fitted out with five kinds of conventional ultrasonic and ray-type devices, for NDT of equipment used in power plants, chemical engineering plants, and oil fields.

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Economic Benefits From 'Spark Plan' Projects Reported

Guangxi Zhuang Autonomous Region

40080130a Tianjin ZHONGGUO JISHU SHICHANG BAO [CHINA TECHNOLOGY MARKET NEWS] in Chinese 14 Jan 89 p 1

[Article by Chen Jianzhao [7115 1696 2507]]

[Text] Science and technology departments in the Guangxi Zhuang Autonomous Region have actively supported the needs in economic development, have become deeply involved in the implementation of the "Spark Plan" project and the "Torch Plan" project, and have moved the science and technology activities in the region toward a new level of practicality and sophistication.

Since the end of 1985, 183 national-level and regional "Spark Plan" projects were initiated in Guangxi to develop cassava, flax and crops, and to work on the Qinzhouwan Integrated Technology Development zone, the Fangcheng and Rongxian model county "Spark Plan" project, the Nanning "Spark Plan Technology Concentration Zone," and the county and village enterprises in the Yulin area. These projects have produced notable social and economic benefits. The 23 projects already completed have resulted in over 300 million yuan of output value and 99.80 million yuan of new profits taxes, and have earned US$16.74 million in foreign exchange. The large area crop projects in 1987 at Baise, Hechi, Qinzhou and elsewhere increased the output of 8.70 million mu of crop land by 286 million kilograms over the 1986 yield. Estimates show that the projects already underway will lead to 1 billion yuan of new output value when they are completed. Among the "Spark Plan" projects implemented in Guangxi, five have received national "Spark Plan" awards offered for the first time.

Now, the "Torch Plan" project, a project that marks a higher level of advancement of technology in Guangxi, has begun in the region. The project consists of a total of 284 tasks of high-technology research. In 1987 four of the biotechnology projects were included in the national high-tech development plan. In 1988 the Guilin-Nanning New-Technology Industrial Zone was formed in Guangxi. Since the formation of the Guilin New Technology Zone in May, a region specialized in electronics and new materials, several hundred senior and middle level science and technology workers in this region and from outside have made urgent requests to start new business and develop new products

in this zone. Companies from 20 countries and regions have contacted the region for cooperative development; the Continental Tire Company in West Germany is willing to cooperate with the development zone to produce 500,000 tires per year. The first 10 projects in the development zone are moving forward steadily.

Zhejiang Province's Shaoxing

40080130b Tianjin ZHONGGUO JISHU SHICHANG BAO [CHINA TECHNOLOGY MARKET NEWS] in Chinese 28 Jan 89 p 1

[Article by Ji Chuanfu [1323 0356 1381]]

[Text] Encouraging results have been obtained in the "Spark Plan" project in Shaoxing, Zhejiang Province, a region designated by the State Science and Technology Commission as one of the concentration areas of the "Spark Plan" project. Among the 74 projects above the municipal level, 33 have already been completed or passed certification; 80 new products have been developed, involving 182 million yuan of new output value and 38.583 million yuan of new profits taxes, and US$10.48 million of foreign exchange were generated.

Spark Plan products produced in Shaoxing have been well received and are gaining publicity. In October 1988, products from Shaoxing entered national and provincial "Spark Plan" result exhibits and received 18.97 million yuan of orders. Shaoxing was awarded four new-product gold medals, three silver medals and three bronze medals in the national exhibit and exchange meeting. It also received the first-place award in the Zhejiang provincial exhibit, plus five new-product first-place awards, six second-place awards and seven third-place awards. In a provincial evaluation of "Spark Plan" progress, Shaoxing was awarded one first prize, one second prize, three third prizes, and one honorable mention group awards and one first-place personal award.

By implementing the "Spark Plan" project, many plants and companies have improved their developmental ability and economic efficiency. In Shangyu Xian, the eight-member companies of the Yuzhong Electric Machinery Technology Group carried out 11 projects and generated 46.3443 million yuan of output value and 12.7195 million yuan of profits taxes. Among these, the 10 products of two national-level projects developed by the Shangyu Blower and Air-Conditioning Equipment Main Plant created 80 percent of the total 25 million yuan output value of the whole plant. The Keqiao Textile Technology Group in Shaoxing carried out 18 subtasks and created 56 million yuan of output value, and 13 million yuan of profits taxes. Compared to pre-"Spark Plan" times, there have been considerable increases in output value and taxes.

Beijing Municipality's Rural Towns

40080130c Tianjin ZHONGGUO JISHU SHICHANG BAO [CHINA TECHNOLOGY MARKET NEWS] in Chinese 1 Feb 89 p 1

[Article by Li Bing [2621 1755]]

[Text] "Spark Plan" projects in Beijing Municipality are spreading out like wildfire. In the past year there were 460 national-, municipal- and ward (county)-level "Spark Plan" projects in Beijing; these projects created 650 million yuan new output value and 170 million yuan in new profits taxes, which are equal to the total output value and taxes, respectively, created in the 2 years of 1986 and 1987.

In the rural villages of Beijing, the projects progressed smoothly. There were 1,580 items of research results, 70,000 management and technical personnel received training, 100 town and village enterprises were "diagnosed," 51 enterprises passed certification, and 11 agricultural system engineering projects progressed nicely, and 10,000 mu of medium-to-low-yield salty and alkaline land in the southeast suburbs took on technical development projects, increasing the yield of the entire municipality's 1.4 million mu of medium-to-low-yield land by 22 percent. In order to develop new stocks of vegetables, three seed bases covering an area of 600 mu were built. These bases have successfully grown 28,000 kilograms of good stock cabbage, kale, cauliflower, sweet pepper, tomato, cucumber, and celery, enough for planting in 150,000 mu of vegetable fields with an economic benefit of 7 million yuan. In addition, 20 more varieties of vegetables were also cultivated and promoted. One hundred mu of strawberry strain breeding ground was also built and four new strains were developed. The new strains lengthened the strawberry season from 1 month to 6 months.

Four "Spark Plan" technology concentration wards (counties) were completed. Zhoukoudian village in Fangshan Ward had a total industrial and agricultural output value of 87 million yuan in 1988, which was 75 percent over the 1987 figure, and created 13 million yuan of profits taxes, 82.6 percent more than that in 1987.

Beijing Municipality paid attention to close cooperation between the associated departments in its implementation of the "Spark Plan" projects. In 3 years, the banks loaned out a total of 250 million yuan for "Spark Plan" projects, the municipal finance department subsidized 3 million yuan of interest per year, and the tax departments gave timely waivers of taxes to these projects. In terms of management, the "Spark Plan" projects and reform were proceeding simultaneously and the county- and village-level technology developments were combined; this ensured that "Spark Plan" projects entered the grassroots level. The Beijing Municipality "Spark Plan" office received a management award, four technology awards, one enterprise demonstration award, and one outstanding youth award. Beijing was second in the number of awards among the provinces and municipalities.

40080130d Tianjin ZHONGGUO JISHU SHICHANG BAO [CHINA TECHNOLOGY MARKET NEWS] in Chinese 4 Feb 89 p 1

[Article by Jin Guoxun [6855 0948 8113]]

[Text] Heilongjiang Province took advantage of the "Spark Plan," the "Bumper Harvest" and the "Wildfire" projects as three movers for the town and country technology and important forces in the development of the national economy. As of the end of 1988, the total town and country enterprise output value was 11 billion yuan, with over 1.5 million employees. These projects have played an increasingly important role in enriching the country and its citizens, in transforming the labor force, and adjusting the city and country industrial structure.

In the "Spark Plan" projects, more than 200,000 workers were organized to attend training sessions and to obtain production knowledge in order to become the backbone of the work force. Today Heilongjiang has formed a preliminary training system, built 12 training centers and schools and has spent an average of 10 million yuan per year on worker education.

Heilongjiang has formed a technology team in the town and country enterprises: there are now 14,000 technical staff and 3,700 middle and upper staff. The number of engineering and technical personnel flowing from research units, large enterprises, and universities to the country enterprises has reached 2,500. Last year, all levels of the provincial government of Heilongjiang assigned some science and technology town and country administrators to selected counties, cities and villages to strengthen the technology leadership.

Since the implementation of the "Spark Plan," the "Bumper Harvest," and the "Wildfire" projects, the scope of technological reform in Heilongjiang has increased every year and a system of infrastructure enterprises has taken shape. From 1984 to the present, Heilongjiang has raised 150 million yuan, implemented 750 technical reforms, and established a family of technologically advanced larger enterprises producing novel products. In the 1988 town and country enterprise gross output value, 675 million yuan were for high-quality products. In 5 years, a total of 156 provincial and ministry approved quality products and 310 town and country quality products have been developed. More than 500 enterprises in Heilongjiang with output values exceeding 1 million yuan have adopted general quality management, and 128 enterprises received level III certificates for general quality management.

The provincial science commission of Heilongjiang has also specified 12 areas for development and helped in establishing a family of key enterprises for technological demonstrations.

Liaoning Province's Anshan

40080130e Tianjin ZHONGGUO JISHU SHICHANG BAO [CHINA TECHNOLOGY MARKET NEWS] in Chinese 4 Feb 89 p 1

[Article by Gao Chengfu [7559 2052 3940]]

[Text] Anshan city in Liaoning Province has actively pursued the "Spark Plan" projects and technology enrichment. In 1988 it raised a total of 5.20 million yuan and extended the 25 projects of the year before. In addition, 20 more projects were initiated, including one listed as a national project and four listed as provincial projects. Since these 20 projects were scientifically designed and properly conducted, all of them were certified in the same year and put into production in the same year, leading to an economic benefit of 41 million yuan.

The implementation of the "Spark Plan" projects mobilized the economic potential of the farms. In Panjialu village, Shahe Xian, Jiubao Ward, a project to produce high-quality magnesium calcium carbon bricks was initiated at the beginning of the year. Six months later production was certified and the output value in the first 6 months was 2.50 million yuan, creating 520,000 yuan of profits taxes. In Monument Township in Haicheng, they developed Dacron film capacitor sealing material and produced 50 tons of this material in 1 year, creating 1.25 million yuan of output value and 360,000 yuan of profits taxes. A bag-type filter was developed in Teng'ao Township in Haicheng. After the filters were used in the steel works, they were praised highly and could not meet the demands. The vibrating drying sieve developed by Teng'ao Township was popular among foreign customers at the Guangzhou trade show and received floods of orders. So far 80 units have been built and created over 600,000 yuan of output value. Many "Spark Plan" projects have caused a large number of town and country enterprises to take off and became the backbone of local economies.

Agricultural projects were led by producing fresh vegetables in winter season; 30,000 mu were developed, resulting in an output value of almost 100 million yuan. This project not only ensured vegetable supply in winter in the Anshan region, but also alleviated the shortage of vegetables in Heilongjiang and Jilin provinces. Xifu Township in Taian county built a production base for raising pigs at a fast growth rate; 940 households in three villages raised more than 10,000 pigs, averaging 11 per household and 2.7 per person, with a maximum of 100 per household. Just this project alone increased the income per person by 300 yuan.

Projects aimed at earning foreign exchange started with the chicken project and extended to mink raising, mushrooms, beef cattle, willow weaving, geese, and feathers. In the 31 towns and villages in Haicheng alone, there were 3,000 households raising more than 4 million chickens per year. In addition to supplying the domestic market, exports generated more than US$3 million.

In the "Spark Plan" projects, Teng'ao township and Shahe village have gradually become two bases of high concentration; an agricultural ecology

demonstration zone was formed at Gengzhuang township. More than 60 percent of the "Spark Plan" and agricultural technology development projects in Anshan were concentrated in these three places. Advantages in manpower, technology, enterprise, resources and capital have begun to form.

In the personnel training activities of the "Spark Plan" projects, 250 sessions were held at the city, county and village levels training 15,000 technical and management people.

The Anshan "Spark Plan" projects have sowed the seeds of technology in the vast fields and benefited the peasants. The national-level project on fast growing cattle has received a national award, and the personnel training task has received a national "Spark Plan" personnel training award.

Tianjin Municipality

40080130f Tianjin ZHONGGUO JISHU SHICHANG BAO [CHINA TECHNOLOGY MARKET NEWS] in Chinese 4 Feb 89 p 1

[Article by Yu Zhiqiu [5713 1807 3808]]

[Text] How should scientists and technical personnel decide their direction of effort when they wish to contribute to the town and country enterprises? A few days ago the Tianjin Municipality "Spark Plan" society held its membership meeting and proposed the topics for the next 2 years.

Since the 3d Plenary Session of the 11th Party Conference, there have been great advances in town and country enterprises and industrialization in Tianjin. By 1990, there will be five "Spark Plan" concentration areas, 10 "Spark Plan" enterprise groups, and 100 "Spark Plan" model enterprises. In order to organize 10,000 technical and skilled people to carry out the "Spark Plan" projects, the society wishes that when its members choose a topic for research and development, they would select topics that require low capital investment but have large and quick returns. Topics not in the society's plan or with limited development should be avoided.

A spokesman of the society said that topics useful to the technical reform of town and country enterprises, reprocessing of agricultural products and by-products, enrichment of people's lives, new enterprises suitable for new villages, and technology that can add value to traditional products should be considered. Also considered are projects that can generate foreign exchange, technologies and products compatible with the "Spark Plan" concentration zones and large enterprises, new materials with specific applications and resources, special chemical fertilizers, new feeds, energy-saving devices and fine chemical engineering products.

Director Li Shufu [2621 2885 1133] of the society spoke at the meeting and encouraged the technical staff to choose good topics to contribute to the town and country enterprises.

Jiangsu Province's Taicang County

40080130g Tianjin ZHONGGUO JISHU SHICHANG BAO [CHINA TECHNOLOGY MARKET NEWS] in Chinese 15 Feb 89 p 1

[Article by Song Zuying [1345 4371 5593]]

[Text] The Kongfu breeding company in Taicang County, Jiangsu Province, conducted a "Spark Plan" project on pigeon breeding and feeding. The project was accomplished 9 months ahead of schedule and the technical and economic targets stated in the contract were all fulfilled. Good results were obtained in stock breeding, establishing feeding practices, disease prevention, and providing services to households raising pigeons.

The Kongfu company has 100 mu of land and 13,000 square meters of buildings, and is one of the larger special avian breeding grounds. In 1984 the company imported 1,900 pairs of breeding pigeons, and in September 1986 the project became one of the national "Spark Plan" projects. The project goals were to have 3,000 pairs of breeding pigeons in 3 years, and production of 27,000 young pigeons per year. As of November 1988, there were 4,190 pairs of breeding pigeons and 46,000 young birds were produced. Project targets on egg production by breeding birds, hatching of young pigeons, survival rate, and weight at 4 weeks have all been overfulfilled. In 3 years the project achieved an output value of 1.369 million yuan, involving profits of 664,000 yuan and per capita profits of 39,000 yuan. A total of 24,773 pairs of breeding pigeons were provided to 1,126 units and individuals in 24 provinces, municipalities and regions. The old hope of benefiting the people by raising pigeons was finally realized.

Importance of Basic, Applied Research

Raising Research to Higher Levels

40080147b Beijing KEJI RIBAO in Chinese 14 Feb 89 p 1

[Article by Han Yuqi [7281 3768 3825] and Wang Jianmin [3769 1017 2404]]

[Text] The national basic research and applied research conference was held in Beijing on 13 February. State Council member and chairman of the State Science and Technology Commission Song Jian [1345 0256] advocated reform and openness and raising China's basic research and applied basic research to a new level. He called for a higher level of funding for basic research.

Song pointed out that the central theme of the conference sponsored by the State Council was to analyze the status and mission of China's basic research and applied basic research, to discuss the policies and measures for enhancing China's basic research and to mobilize the intelligence and talents of science workers.

Song said that basic research is the preamble of new technologies and new inventions. More and more governments and economies in the world have realized that basic research is the basis for social and economic developments and technological advancements, the window for international exchanges, the basin for personnel training, and the cornerstone for modern culture. Strength in basic scientific research is an important factor that affects the overall force of a nation, and one of the prerequisites for defense modernization.

Song said that the main tasks of basic research are to explore and discover new phenomena and new rules, and to establish new concepts and new theories and to investigate new applications. From a general and long-term point of view, basic research is crucial in achieving China's long-term development strategy. Basic research must therefore be treated as an important component of China's overall science and technology enterprise. To maintain steady and sustained development in basic research is a long term and fundamental goal of our party and country.

Song said that the scale and priorities of basic research must on the one hand follow the rule and trend of modern scientific and technological developments, and on the other hand suit China's current situation and be compatible with the economic resources and development standards of the country. Today there are a number of major and urgent problems in the development of the national economy and society, such as agriculture, energy, resources, environment, and population. For a number of years in the future, we will aim at major problems related to our citizen's life and our nation's future. Research will be given priority, research topics will be selected, research teams will be organized, and a number of steady directions will be established in basic research.

Song urged people to pay special attention and protect middle-aged and young scientists with unique and novel scientific talents so that they may work at the leading edge of modern science. On the issue of how to evaluate basic research, Song commented that scientific merit and social value must be placed at the top of the list. Basic research should not be evaluated with criteria for development work. In this regard, short-term behaviors are often more disadvantageous and should be carefully guarded against.

Song said that in the near term funding of China's basic research will be mainly from government allocations. At the present time investment in basic research is low and funding is insufficient; as a result, many talented people cannot contribute effectively and facilities bought with large sums of money cannot play their intended role. In the future steps should be taken to increase funding and increase the percentage of basic research in allocations for science. Based on China's economic situation, we believe that the investment percentage on basic research should be increased in two steps: by the end of the Seventh Five-Year Plan, the percentage should be increased from the current 7.1 percent to 8-9 percent, and, at the beginning of the 1990's, to 10 percent or higher. The increase in percentage should start this year and, after a few consecutive years of percentage increases, investment in basic research will be at a properly adjusted level.

Song also said that efforts should be made to gain society's support and to increase income through international cooperation. Medium and large enterprises, especially enterprise groups, should be encouraged to establish basic research foundations. A system of foundations should be set up by developing professional foundations, local foundations, and private foundations. Science and technology expense allocations should be made on a merit basis and the previous practice of allocating funds according to head count must be abolished. Research units engaged in basic research will still receive gradually increasing expense allocations, but such allocations must be made on a contract basis, the allocated money will not increase when personnel increases, nor will the allocation decrease when the number of people decreases. Basic tasks such as long term sample collection, observation, accumulation, analysis, data processing and data

base management should be supported in the various natural sciences areas. Large scale projects such as high energy physics and nuclear research facilities will have to rely on government allocations. In the future, such projects should be preceded by feasibility studies of the technology and the selection of projects must be made carefully following scientific and democratic steps.

Song pointed out that basic research requires a sound academic environment. In such an environment, researchers are encouraged to develop their individual ability for reasoning and to engage in creative endeavor; academic ideas are exchanged freely and thoroughly; mid-term and long-term investigations are expressly identified to be free from the constraints of market needs and economic goals; creative scientific research not yet appreciated by the general public should be supported and protected. Priority national laboratories should have a small number of permanent staff and a large number of visitors to form a structure based on visiting scholars. Open laboratories should be periodically evaluated; unsatisfactory laboratories must be given a deadline for improvement, otherwise the administrator will be replaced or the laboratory will be closed.

Song stressed the importance of the dynamic stability of a research team. On the whole the research team should be competent and stable, but locally there should be movement. All the research units should be thoroughly reformed and organized optimally. The assignment of graduate students should also be improved; in principle, they should move on to other organizations in order to avoid "inbreeding."

Finally, Song believes that people are key to the development of basic research. Youth is the hope of our future scientific enterprise. He advocated the establishment of a youth science foundation to select good quality, ambitious, capable and dedicated young scientists to join basic science research. Governments and research units must also take specific action to gradually improve the compensation researchers are receiving, which tends to be less than that received by similar technical people. Researchers should be allowed to supplement their income by taking on more than one job. Basic research is a hard exploratory endeavor which takes scientists years, decades, or even a lifetime to pursue. Their work should be appreciated and supported by the whole society and their achievements should be encouraged and respected by the government and society.

Qian Xuesen on Basic Research

40080147c Beijing KEJI RIBAO in Chinese 24 Feb 89 p 1

[Article by Wang Jianmin [3769 1017 2404] and Han Yuqi [7281 3768 3825]: "Qian Xuesen Stresses Basic Research of Applied Technology"]

[Text] Famous scientist and chairman of the China Science Association Qian Xuesen [6929 1331 2773] spoke at the National Basic Research and Applied Research Conference. His report, "Basic Research Revisited," discussed pure

basic research and basic applied research in natural sciences. According to Qian, the goal of so-called "pure research" is the understanding of nature and the laws of nature. Pure research has no obvious direct applications; it is based on the internal rule of scientific development and is an exploration of new prospects and unknowns, based on known knowledge, on the frontier of scientific development. We explore the laws of nature under the guidance of the Marxist philosophy; all new findings will enrich our view of the world and the Marxist philosophy, which in itself is an important undertaking. In addition, the final goal of understanding nature is to modify nature for the betterment of mankind. Hence, without direct applications does not mean irrelevant to the social and economic development of mankind. In the history of scientific development, many important discoveries did not have clear applications when they were made, but their significance became realized in the course of further development. All scientifically important discoveries of new understandings of nature and the laws of nature will have a significant impact on the formation of a scientific world view and on the creation of new wealth in society.

Qian continued to say that basic applied research includes the basic studies of applied sciences and applied technologies. The reason that he brought out basic research of applied technology was that when people talked about applied basic research, they often referred to basic studies of applied science and ignored the basic research of applied technology. Applied technologies are precisely the obstacles in our present major production industries related to the citizen's life. The difference between basic research of applied sciences and basic research of applied technologies is that the former refers to developmental or long-term research with a specific application and aimed at breakthroughs in a certain scientific field. Basic research in applied technology, in the case of China, is largely of a remedial nature, with its primary goal not to achieve major breakthroughs but to grasp existing foreign technology; not only to know how but also to know why, so that these technologies can be absorbed and utilized by China. Based on that, we can then build our own technology base and strive for innovations and developments.

Qian pointed out that many of our important products are of poor quality and the consumption of raw materials and energy is high. Chinese products not only lack competitive power on the international market, but face the pressure of imported products even in the domestic market. What causes this situation is not a lack of understanding of some fundamental scientific principle, but a lack of our own technological basic research.

Qian emphasized that applied basic research should not only be stressed in the Chinese Academy of Sciences and in universities, but also in industrial

departments. The industries should list the important applied basic research one by one and provide adequate funding for them. Researchers in the Academy and in the universities should cooperate with the science and technology force in industry so that a world class technology base can be established as soon as possible.

Qian believes that there should be a policy to increase investment in basic research and basic applied research so that there will be a considerable growth after adjustment for inflation. Academic democracy should be advocated, and the researchers should be provided with an efficient working and living environment in order for them to do research with no distraction.

Shanghai Institute of Technical Physics Has Key R&D Mission

40080115a Beijing GUANGMING RIBAO in Chinese 8 Jan 89 p 1

[Text] Last year, when the Shanghai Institute of Technical Physics of the Chinese Academy of Sciences was evaluating personnel for senior positions, some comrades felt that those under consideration who were engaged in technology development, had not produced acceptable treatises and were doubtful as to whether or not they would be promoted. The institute's leadership and the evaluation committee were of the opinion that the economic benefits created by those comrades involved in development and their management competence must be given primary consideration. The result was that three S&T people involved in development were selected as senior engineers. This represents one-quarter of the institute's senior positions awarded for the year.

"Research work and development work each has its own regulations, we insist on using different concepts of value and different criteria in assessing the work of people in each section." Institute Director and Researcher Kuang Dingbo thus explained the above matter to this reporter.

The Shanghai Institute of Technical Physics is a large institute employing over 500 research personnel and nearly 1,000 staff and workers. It is primarily involved in the application and research of infra-red photo-electric and remote sensing technologies. Today, it has responsibility for key project applications missions of R&D on remote sensing instruments for the national weather satellite. There is one open laboratory engaged in basic research into infra-red physics and several companies developing products incorporating high-level infra-red technology.

The research institute has adopted methods of the high-tech product and technology responsibility system in managing project applications missions such as the R&D for the national weather satellite remote sensing instruments. The task is broken down according to specialized technical fields and delegated to the institute's eight departments. The departments set up master systems designers, designers responsible for components, technicians and reliability engineers and also clarify each level of technical responsibility.

In managing the open infra-red laboratories the research task appraisal through discussion style, as implemented by academic committees composed of well-known scholars both in this country and abroad has been adopted. Companies are economic entities with legal person status, therefore, if the research institute is to act as an investor in the development of technology, this must pass through a board of directors which carries out macroscopic management of the company's business.

Regarding distribution, the research institute follows the principle that each department has its role to play and stresses good handling of the proportional relationship between them. Incentive bonuses for the project applications department are drawn from monetary rewards (the source of monetary rewards is 3.5 to 5 percent of the contract orders for goods). Incentive bonuses and wages for the technology development department are entirely paid by the department itself. Incentive bonuses for the basic research and administrative service departments are drawn from funds handed over by the departments engaged in project applications and technology development.

Evaluation for promotion does not only consider records of formal schooling and treatises. The use of different concepts of value in the assessment is insisted upon. Technical personnel responsible for the project applications mission lack the time to write abstruse papers and yet they have overcome very many difficulties in high-technology. Those comrades engaged in technology development have no basis for claiming any kind of award for S&T accomplishment, while they have created excellent economic benefits. Those doing basic research and issuing papers can lay claim to many awards, but usually the economic returns they create are fewer than those of the other sections.

Last September, China launched its first weather satellite and a scanning radiometer developed by the Shanghai Institute of Technical Physics was tested. After clearly and reliably sending images from an altitude of 901 kilometers, it received good evaluations from our country and abroad. Afterward, the institute's open laboratory for infra-red physics ranked in the top five in the Chinese Academy of Science's comparative appraisal of 19 open laboratories and received a commendation. At the end of last year, a reporter obtaining interviews at the institute came upon several of the independently and cooperatively funded companies engaged in year-end accounting. The Defu Company, employing just over 40 people, is one of this institute's high-tech enterprises started through independent funding which concentrates on the production of infra-red alarm instruments. Last year's sales totaled 2 million yuan with profits of 600,000 yuan and a per-capita profit generation of over 10,000 yuan. Another company which is jointly financed with a Japanese ceramics corporation and the Shanghai Nisaila Sensor Company Ltd., exports 95 percent of its products and had an output value last year of 1.7 million U.S. dollars, with a per-capita profit generation of 14,000 U.S. dollars, placing it at the forefront of Shanghai's 323 cooperatively financed manufacturing enterprises.

The institute's Assistant Director Yan Yixun explained that at present, developmental work does not only solve the job security problems of the people in one's own department and an independent capacity for development now exists. Moreover, there is new support for basic research and for each of the institute's projects. This is a beneficial trend which has never before existed in the decades-long history of the research institute.

Report on Analysis of Rocket Engine Wall Temperatures

40080101a Shanghai SHANGHAI JIAOTONG DAXUE XUEBAO [JOURNAL OF SHANGHAI JIAOTONG UNIVERSITY] in Chinese Vol 22 No 6, Nov 88 pp 12-19

[Article by Cheng Hui'er [4453 1920 1422], Department of Power-Generating Machinery Engineering: "Numerical Analysis and Applications of the Response of Liquid-Propellant Rocket Engine Radiation-Cooled Thrust Chamber Wall Temperatures"; manuscript received 26 May 1987]

[Text] **Abstract:**

Using the self-developed LRETC-I computer program, we have made a numerical analysis of heat transfer characteristics of a 490-newton radiation-cooled thrust chamber. This analysis included heat-flow density distribution and chamber wall temperature response, as well as the effects on residual oxygen coefficients for adjacent wall layers and on the physical parameters of chamber wall materials. We compared the calculations with experimental test values from the well-known R-4D engine, with fine results. The analysis and computer programs presented in this paper can be used for the design of liquid-propellant rocket engine radiation-cooled thrust chambers.

I. Introduction

Differing from the regenerative-cooled large liquid-propellant booster rocket engines, many space engines use structures that are combinations of extrusion delivery systems and regenerative-cooled/radiation cooled [systems] (as for example the liquid long-distance engines used by Symphonie [two Franco-German communications satellites launched in 1974-75]) or completely radiation-cooled thrust chamber structures. Chemically correct quantities of near-wall layers (adjacent) cooling liquid film can ensure the formation of lower adjacent oxygen residue coefficients, which allows the engine to operate reliably. This paper presents a theoretical numerical analysis of the heat transmission characteristics of a completely radiation-cooled thrust chamber. Then, after linking this with experimental values, we can make predictions about the thrust chamber near-wall layer oxygen residue coefficient α_b. We need not measure the radial conduction of the entire calculated hypothetical thrust chamber, and may disregard the internal and external radiation exchanges between chamber walls, as well as the radiation dissipation effects of the ejector nozzle; nor do we consider the radiation heating of the ejector nozzle surface by the flame. All these

things aside, we consider the heat properties of the chamber wall materials to be a constant.

II. The Calculation Equations

It may be predicted that when there are radiation boundaries, the temperature differential equations for the many nodes in the thrust chamber walls are nonlinear. The basis for the calculations in this paper is the form after linearization, that is,[1]

$$A_i T_{i-1}^{n+1} + B_i T_i^{n+1} + C_i T_{i+1}^{n+1} = D_i T_i^n + E_i$$
$$i = 0,\ 1,\ 2,\ \cdots,\ L$$
$$n = 0,\ 1,\ 2,\ \cdots \qquad (1)$$

where

$$A_0 = 0$$

$$A_i = -\frac{\lambda F_{1,i}}{\Delta x_{i,-}},\quad i = 1,\ 2,\ \cdots,\ L$$

$$B_0 = \frac{\lambda F_{2,0}}{\Delta x_{0,+}} + \alpha_0^n F_{3,0} + 4\varepsilon\sigma_0 (T_0^n)^3 F_{4,0} + \frac{\rho C V_0}{\Delta\tau}$$

$$B_i = \frac{\lambda F_{1,i}}{\Delta x_{i,-}} + \frac{\lambda F_{2,i}}{\Delta x_{i,+}} + \alpha_i^n F_{3,i} + 4\varepsilon\sigma_0 (T_i^n)^3 F_{4,i} + \frac{\rho C V_i}{\Delta\tau}$$

$$i = 1,\ 2,\ \cdots,\ L-1;$$

$$B_L = \frac{\lambda F_{1,L}}{\Delta x_{L,-}} + 4\varepsilon\sigma_0 (T_L^n)^3 (F_{2,L} + F_{4,L}) + \alpha_L^n F_{3,L} + \frac{\rho C V_L}{\Delta\tau}$$

$$C_i = -\frac{\lambda F_{2,i}}{\Delta x_{i,+}},\quad i = 0,\ 1,\ 2,\ \cdots,\ L-1$$

$$C_L = 0$$

$$E_i = (\alpha_i^n T_r + q_{r,i}) F_{3,i} + \varepsilon\sigma_0 T_\infty^4 F_{4,i},\quad i = 0,\ 1,\ 2,\ \cdots,\ L-1$$

$$E_L = \varepsilon\sigma_0 T_\infty^4 F_{2,L} + (\alpha_L^n T_r + q_{r,L}) F_{3,L} + \varepsilon\sigma_0 T_\infty^4 F_{4,L}$$

Equation (1) is a completely implicit form, and if written in a matrix form, the coefficient matrix for node T_i^{n+1} is a tridiagonal matrix, where there are nonzero elements only on the leading diagonal and on the two adjacent diagonals. Therefore, we may solve this using the "pursuit method."[2]

III. The Selected Calculation Parameters

1. The combustion restoration temperature T_r

For the supersonic nozzle flow, for the combustion temperature in the Newtonian convection heat-exchange equation, we should get the restoration temperature T_r, which can be expressed as:

$$T_r = rT_0 + (1-r)T_g \qquad (2)$$

where $r = Pr^{\frac{1}{3}}$

$$Pr = \frac{4k}{9k-5}$$

$$T_g = \frac{T_0}{\left(1+\frac{k+1}{2}M^2\right)}$$

$$\varepsilon' = \frac{1}{M}\left[\frac{1+\frac{k-1}{2}M^2}{1+\frac{k-1}{2}}\right]^{\frac{k+1}{2(k-1)}}$$

When calculating the nozzle flow combustion static temperature T_g, we should get the theoretical combustion temperature for the overall temperature T_0.

2. The combustion convection heat-exchange coefficient α

This is normally calculated with the Bartz equation.[3]

3. The combustion radiation heat-flow density q_r

The calculation of q_r is a rather thorny problem. Theoretically, it requires that we determine the average ray range of the combustion toward different positions on the wall surface, and that we gain full control of the radiation characteristics of the central layer, the inner layers, and the adjacent layer. This paper does not study the theoretical calculation methods for the radiated heat-flow densities of combustion within the combustion chamber, but rather proposes a simple and reasonable q_r distribution model for use in the calculation of wall temperatures based upon combustion flow characteristics and temperature characteristics, which is similar to calculations of heat transmission in regeneratively cooled thrust chambers. The specific distribution of q_r is:

$$q_r = \begin{cases} 0.2\,q_{r,max} + 0.8\,q_{r,max}\left(\frac{2x}{L_1}\right), & 0 \leqslant x \leqslant 0.5\,L_1 \\ q_{r,max}, & 0.5L_1 \leqslant x \leqslant L_1 \\ q_{rmax} - 0.98 q_{rmax}\left(\frac{x-L_1}{L_5-L_1}\right), & L_1 \leqslant x \leqslant L_5 \end{cases} \tag{3}$$

where

$$q_{r,max} = 0.65\left(\frac{\varepsilon_w+1}{2}\right)\sigma_0 \varepsilon_g T_0^4 \tag{4}$$

Here, the combustion temperature T_0 and the degree of combustion blackness ϵ_g should be calculated in accordance with the average composition ratio. Obviously, the three-broken-line model for radiation heat-flow density q_r distribution affects some traces of the regenerative cooling model, but in principle it accords with the fundamental characteristics for ignition and flow in the rocket thrust chamber.

4. **Rocket thrust chamber combustion performance**

This is obtained from reference [4].

IV. Calculation Examples and Analysis

We have written computer routines using the calculation equation (1), and have also done a numerical analysis of the heat-transmission characteristics for the completely radiation-cooled thrust chamber of a typical long-distance liquid-propellant rocket engine. The primary characteristics for which we have calculated are: ignition chamber pressure p_c = 0.7 MPa, the propellant is dinitrogen tetroxide and monomethyl hydrazine combined at a ratio of 1.90:1, and the chamber wall material is a niobium alloy. This is extremely close to the well-known R-4D engine.

The initial chamber wall temperature T(0,x) equals 288K, and since long-range rockets operate at high altitudes of about 36,000 km, for the side opposite the sun, we may disregard the sun's radiation and the radiation of other celestial bodies, which is to say, we consider the engine to be in an environment of $T_{infinity}$ = 0 K.

We divide the thrust chamber axially into five divisions: the cylinder section, the convergence section, the fore-throat, the aft-throat, and the diffuser (expansion section). Then, we make n portions from each division, thereby obtaining a total of 5n+1 locally distributed chamber wall nodes (units). Experience has shown that this kind of division is well matched to the conflicts between the computer precision and the calculation times. The distribution of the chamber wall nodes is shown in Figure 1 (where n = 4). See Figure 2 for the main block diagram. We use $\Delta\tau$ = 0.1 second for the calculation time step length.

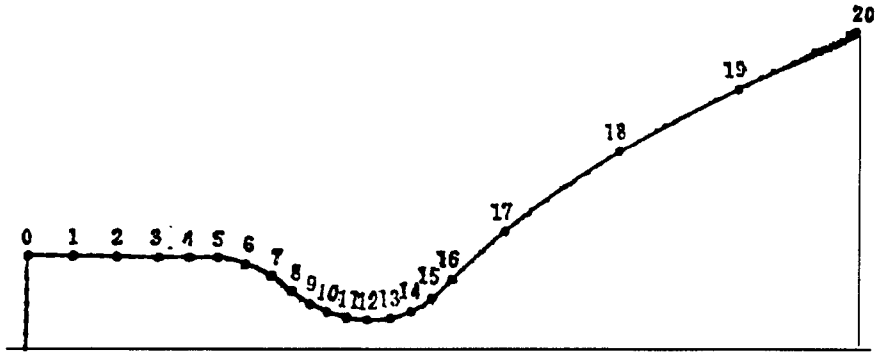

Figure 1. Chart of Thrust Chamber Wall Node Disposition

1. Wall temperature response

We can see from the temperature curve in Figure 3 that during the first few seconds after rocket ignition, the thrust chamber wall temperature T_w rises abruptly with time τ, and later, the rate of change for T_w within time τ

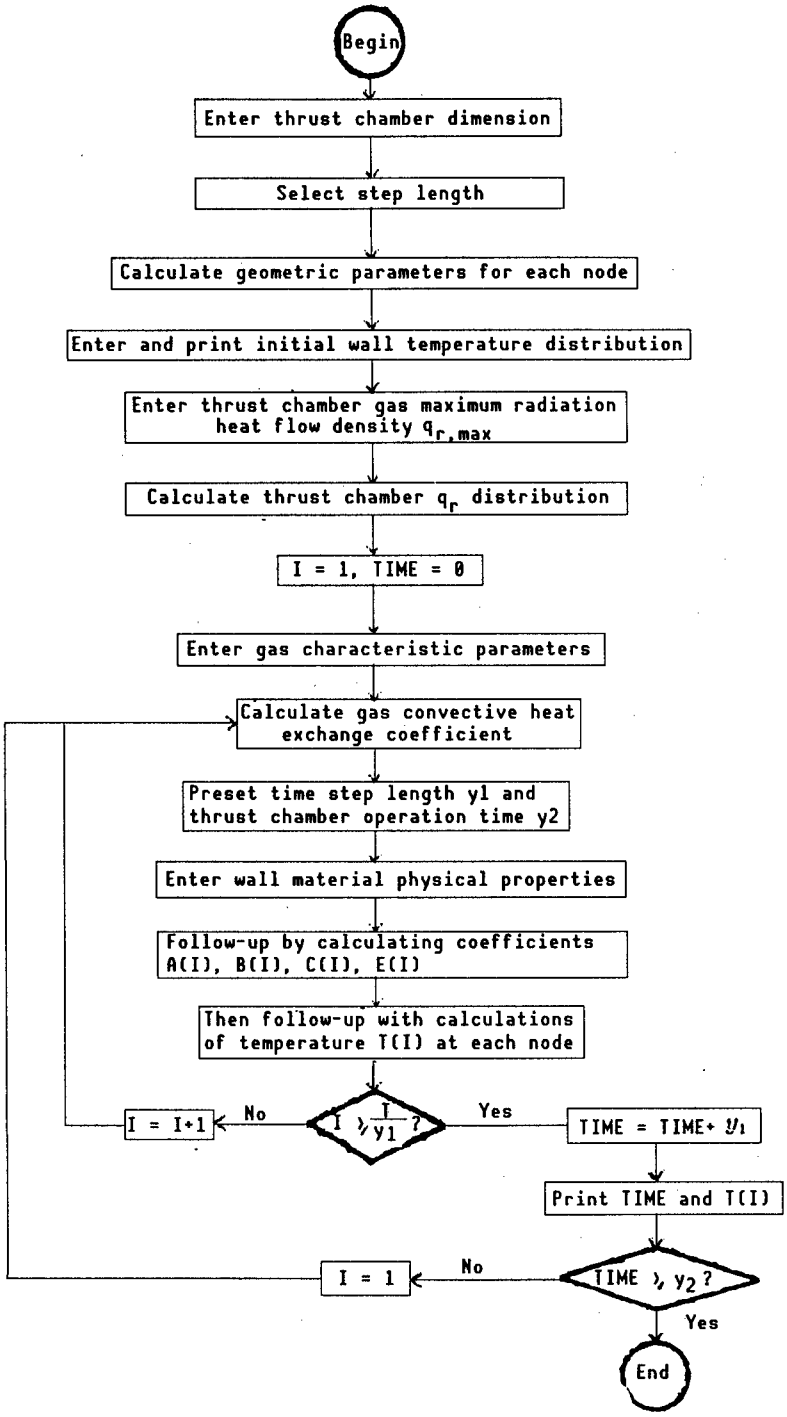

Figure 2. Primary Flowchart for Computer Program

diminishes quite clearly, and only after about 50 seconds does the entire thrust chamber wall temperature not change again (aside from the vicinity of the nozzle), so the time required for the heat to stabilize is much greater than for regeneratively cooled engines. The characteristics of wall temperature distribution are: temperatures will be highest in the area of the throat, and the sides will drop rapidly, with a greater decline in temperature. The point of highest temperature on the wall will increase with time progressively from the convergence section toward the nozzle throat closure (see the path of the dotted line in Figure 3).

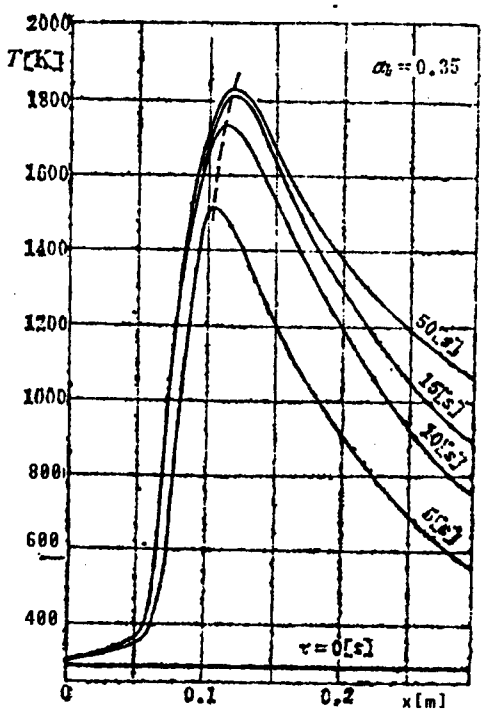

Figure 3. Calculation Results for Wall Temperature Response

This wall temperature response characteristic of a radiation-cooled thrust chamber is created by the different time constants τ^* of the wall units. As can be seen in Table 1, the time constant for the i = 8 node (located in the convergence section) is clearly less than that for other nodes on the nozzle. Therefore, after engine operation, the wall temperature at this position is first to rapidly increase (for the i = 0 and i = 2 positions in the cylinder section, as long as their time constant is less than that of the i = 8 node, their response will be the lowest liquid film or gas film, and is not the highest ignited gas temperature). Naturally, strictly speaking, the several elements in the thrust chamber wall should not be seen as a system of several internal heat groups that can be disregarded, but rather we should consider that axial conduction is certainly not dominant, and that the environmental conditions for wall surfaces outside the thrust chamber are basically also completely homogeneous. In these particular conditions, if we assume that the gas boundary parameter αF_3 reflects the heat perception conditions of each element, and use ρCV to reflect the heat capacity of each element, then their proportion, that is, what we are

calling here the thrust chamber element (nodes) time constant $\tau^* = \rho CV/\alpha F_3$ is still sufficient to become an effective index for characterizing the amount of thermal inertia. Elements with smaller time constants have an even quicker response to gas temperature. At the test site one can see the following characteristics of wall temperature changes: the first thing after ignition is that the nozzle entrance position, that is, the convergence section, burns red, only after which does the high-temperature zone gradually move toward the throat section.

Table 1. Nodes Time Constant

Node symbol	ϵ'	τ^*[s]
0	3.90	0.90
2	3.90	0.90
4	3.88	4.70
6	3.44	4.30
8	2.21	4.20
10	1.24	5.70
12	1.00	6.00
14	1.20	6.30
16	1.94	5.70
18	22.71	19.20
20	46.90	34.20

2. Distribution of heat-flow densities

Figure 4 shows the situation regarding the distribution of heat-flow densities for a thrust chamber wall surface model. In the figure, q_1 is the overall heat-flow density distribution for the gas against the wall surface, q_2 is the distribution of heat-flow densities of the wall surface for vacuum-radiated heat dispersion, and therefore q_1-q_2 represents the sum of the amount of heat absorption of the chamber wall material and the amount of axial conduction. At any time, q_1 is always maintained at a maximum at the throat because the intensity of heat exchange is greatest there, and as time passes, the total level will gradually decline because the level of the wall temperatures gradually increases. q_2, on the other hand, is always resolved by wall temperature, and therefore increases with time, its highest point gradually shifting from the convergence section toward the throat position, and the overall level will constantly increase. At the nozzle entrance, heat-flow densities along the direction of the cylindrical section will abruptly decrease, which is because of the effect of the strong separation caused by the boundary cooled liquid film. This greatly weakens the gas radiation conduction reaching the wall surface, finally forcing the temperature there to decrease to a level of only some tens of degrees Celsius.

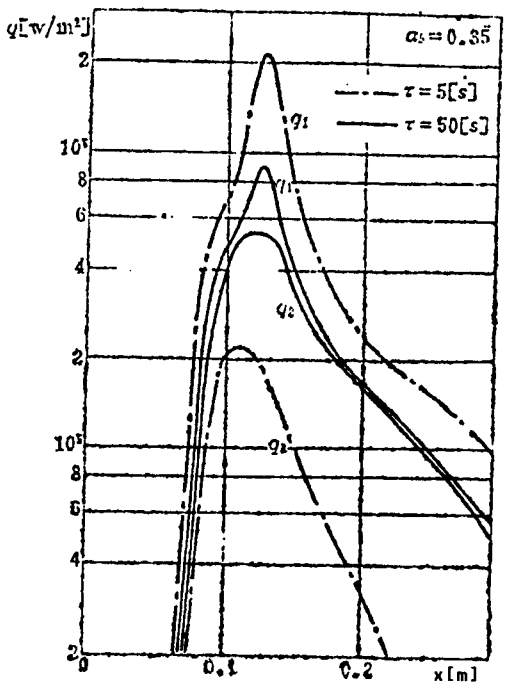

Figure 4. Distribution of Thrust Chamber Heat-Flow Densities

3. Use of the results of wall temperature response calculations

Based on the results of wall temperature laboratory tests and the design values for the thrust chamber boundary oxygen residue coefficient α_b, we can amend the calculation curves given in this paper. But in consideration of these current calculations of α_b, we see that in reality there is a great deal of subjective arbitrariness, and therefore, this revised base is unreliable. Given this, instead of bringing time factors into proofs of allocated shares of boundary cooling liquid-film quantities, it is better to directly apply the wall temperature theoretical calculations and the results of laboratory experiments in determining the real values of α_b at the time of engine operation. As an example, Figure 5 shows empirical values for wall temperatures for heat in the American R-4D engine thrust chamber after stabilization. We can see from this chart that if we figure α_b for the R-4D engine thrust chamber to be largely between 0.31 and 0.33, positions on the same cross-section will exhibit two different sets of wall temperature test data, which is the result of unequal distribution of the boundary liquid-film.

4. The effects of the heat properties of chamber wall material on wall temperature

Figure 6 shows the effects of the chamber wall material conduction coefficient λ and the external surface radiation rate ϵ on the wall temperature T_w distribution. It is easy to see that use of highly conductive and highly radiative materials to create radiation-cooled thrust chambers will aid in reducing wall temperature, or, that it will raise the boundary α_b. The calculations show that when the material's ϵ is increased from

0.7 to 0.95 (which can be done by flame plating a high-ϵ-value plating), the advantage for the chamber walls is a reduction of about 40 K in temperature; when the material conductivity coefficient increases from 60 W/(m•K) to 120 W/(m•K), the throat temperature will also be reduced about 40 K. ϵ and λ increase at the same time, and the totals will force a drop in the throat wall temperature of 90 K. If we continue to maintain the wall temperature T_w unchanged, a drop in temperature of 95 K will bring a gain in the mixture ratio to $\Delta\alpha_b = 0.03$.

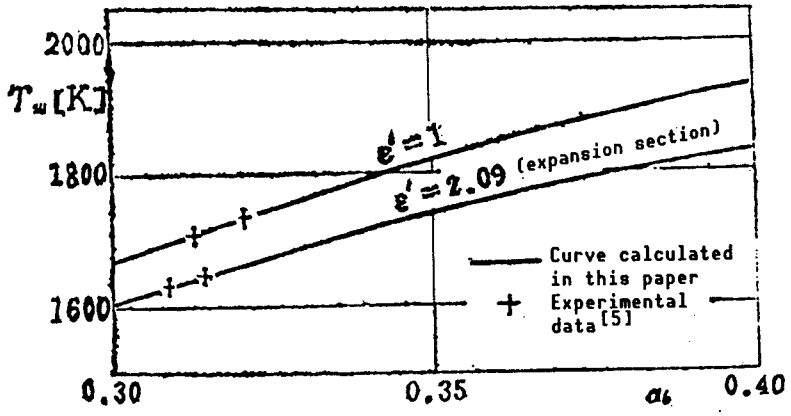

Figure 5. Corresponding Relations Between Boundary Residual Oxygen Coefficient α_b and Wall Temperature T_w

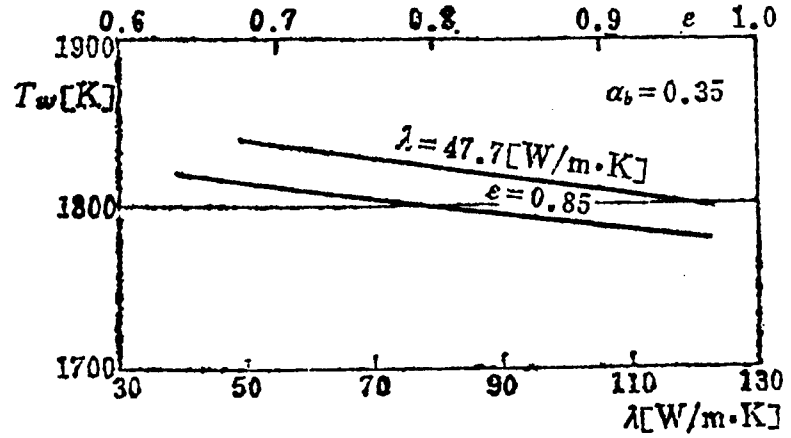

Figure 6. The Effects of the Physical Properties of Chamber Wall Materials on Throat Wall Temperatures

To estimate the error brought about by neglect of radial conductivity, we use a simple plane one-dimensional steady-state conduction equation to obtain the chamber wall radial temperature differential just mentioned for three characteristic positions: for the nozzle entrance ($\epsilon' = 3.88$), the radial temperature differential is $\Delta T = 12°C$; at the throat position ($\epsilon' = 1$), $\Delta T = 70°C$; at the nozzle aperture ($\epsilon' = 47$), $\Delta T = 1°C$. We know from this that if we are to more accurately understand the rules for temperature distribution for chamber walls in the throat area, we must consider the radial changes in temperature, and do our analyses and solutions in accordance with two-dimensional unstable temperature fields. As for positions, simple hypotheses that do not consider radial conductivity

will not introduce much error. Whether looking at this problem from an engineering or theoretical perspective, for chamber walls where the temperature can be as high as from several hundred to 1,000 K, there is no value in insisting upon maintaining approximately 10 K or smaller temperature differentials in the directions of wall thickness.

V. Conclusions

1. By using the LRETC-1 computer programs written for this paper, we can conveniently obtain the response characteristics for liquid-propellant rocket radiation-cooled thrust chamber wall temperatures, and can find the eventual chamber wall heat equilibrium temperatures and heat stabilization times.

2. The calculations presented in this paper coincide with measured wall temperatures, and we can determine the actual value for the thrust chamber boundary residual oxygen coefficient α_b, which then provides a reliable basis for the design of head-section jets.

3. Unlike the principal rocket, liquid-propellant space engines often require multiple starts. The calculations in this paper can provide the initial conditions for the calculation of thrust chamber wall temperatures after engine flameout. This ensures that wall temperatures adjacent to positions in the head portion when turned off will not exceed stipulated values, which is a particular problem for designers of this type of liquid-propellant engine.

4. Figure 6, which has been derived from a great deal of computation, can be used to estimate the response of chamber wall material conductivity coefficient λ and the surface rate of radiation ϵ on the distribution of wall temperatures.

5. The analysis in this paper did not calculate interacting radiation within the thrust chamber and losses from heat dissipation for surface radiation passing the aperture. If we are to understand the effects created by these things on wall temperatures (primarily the wall temperatures in the nozzle extension), then we must calculate the angle coefficients for the chamber wall internal radiation and the angle coefficients for different chamber wall positions in relation to the ejector. Analysis of this question will require specialized research.

Symbol Table

C	chamber wall material specific heat, J/(kg•K)
F_1	area of node left extremity, in square meters
F_2	area of node right extremity, in square meters
F_3	internal node area, in square meters
F_4	external node area, in square meters
k	adiabatic index
L_1	length of cylindrical section, in meters
L_5	total length of thrust chamber, in meters
M	Mach value

p_c combustion chamber pressure, MPa
Pr gas Prandtl number
q_1 total heat-flow density caused on wall surface by gas, W/m^2
q_2 wall surface radiation dissipation heat-flow density, W/m^2
r recovery coefficient
T temperature, Kelvin (K)
T_g gas static temperature, K
T_r gas recovery temperature, K
T_0 gas overall temperature, K
$T_{infinity}$ environment temperature, K
V volume occupied by a node, in cubic meters
x axial distance calculated from the head section, in meters
Δx axial length occupied by a node, in meters
$\Delta x_{i,-}$ distance between the first i and the i-1 node, in meters
$\Delta x_{i,+}$ distance between the first i and the i+1 node, in meters
α gas convective heat exchange coefficient, $W/(m^2 \cdot K)$
α_b boundary residual oxygen coefficient
ϵ rate of wall surface radiation
ϵ' ratio of surface area
λ chamber wall material conductivity coefficient, $W/(m \cdot K)$
ρ chamber wall material density, kg/m^3
σ_0 Stefan-Boltzmann constant, $5.67 \times 10^{-8} W/(m^2 \cdot K_4)$
τ time variable, seconds
τ^* node time constant, seconds
$\Delta\tau$ length of time step, seconds

Subscripts:

cr nozzle throat position
i node position sequence
max maximum value
n time step sequence
w wall surface

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Launch and Orbital Insertion of Geostationary Satellite

40080131a Tianjin ZHONGGUO JISHU SHICHANG BAO [CHINA TECHNOLOGY MARKET NEWS] in Chinese 1 Feb 89 p 4

[Text] Under the control of the Xi'an Satellite Tracking and Control Center, an operational communications satellite was launched at 2040 hours on 22 December of last year, and accurately positioned at 110.5°East longitude at 1232 hours 8 days later. The success of this launch demonstrated the maturity of China's launch and control technologies for geostationary satellites.

Orbit insertion of geostationary satellites is a highly complex process which involves many sophisticated technologies; generally, the entire process takes 10-20 days from launch to orbit insertion. At present, only the United States, the Soviet Union, China, the European Space Agency, and Japan have the capability to launch such satellites. In terms of launch methodology, most countries use the efficient transfer orbit approach. With this approach, the booster rocket and the satellite are both injected into a circular parking orbit several hundred kilometers in altitude by the first ignition of the third stage. The satellite remains in this orbit until it crosses the Equator, at which point the second ignition takes place and sends the satellite into an elliptical orbit with a maximum altitude of 35,860 km. When the satellite reaches the apogee point, the apogee motor on the satellite is activated, which provides the energy to change the orbit plane and to inject the satellite into a geostationary orbit.

This same method was used to launch and position this operational communications satellite and three previous geostationary satellites. Propelled by the Long March-3 booster rocket, this new satellite lifts off the ground swiftly, and continues to accelerate as thrust is generated successively from each stage of the rocket. In the meantime, the satellite is being tracked and controlled in real-time by the Xi'an Control Center and other tracking stations in the region. The first two rocket stages are automatically separated from the satellite after burn-out. The third stage, which is a hydrogen-oxygen engine, injects the satellite into a 200-km, 31°-inclination circular orbit; it remains attached to the satellite and continues to travel in the parking orbit. When the satellite crosses the Equator, the hydrogen-oxygen engine is again activated to send the satellite into an elliptical orbit. At this point, which is only 20 minutes from lift-off, the rocket is

separated from the satellite, and the satellite begins to spin about its own axis to maintain attitude stability. Under ideal conditions, the satellite spends 37 hours in the transfer orbit, during which time several attitude-control and spin-control maneuvers must take place before it enters its final orbit.

The key to accurate orbit insertion is the continuous monitoring and control of the satellite during its transition phase from the elliptical orbit to the pseudo-geostationary orbit. Since China has no ground stations abroad, the difficult task of tracking and controlling the satellite must be accomplished by the Xi'an Control Center and the regional tracking stations, which only have 10 hours of visibility of the satellite during the 37-hour transfer orbit. The fact that orbit insertion was successfully completed under these restricted conditions was a tribute to the Chinese scientists and technicians and their achievement in control technology.

Three-Dimensional Geometric Modeling From Photographs

40080131b Beijing JISUANJI SHIJIE [CHINA COMPUTERWORLD] in Chinese No 6, 8 Feb 89 p 42

[Article by Yu Xinhua [0060 2450 5478] and Tang Rongxi [0781 2837 6932]]

[Text] Potentially, the combination of image processing techniques and interactive graphic display techniques have a broad range of applications. In China, significant progress has been made in the area of map scan-input, editing and construction of data base in vector form for both commercial and military applications. The scan-input and reconstruction of engineering drawings play an important role in CAD/CAM technology. Many factories and design institutes typically have several hundred thousand production, assembly and design drawings; it would be highly desirable to find a simple and efficient way to read these information into a computer for implementation in the CAD/CAM system. In 1986, a U.S. company offered $30 million to have 200,000 mechanical drawings read into a computer, which averaged $150 per drawing. But one of the requirements was to maintain accurate drawing data in vector form; for example, if the distance between two points on a drawing is specified to be 15 inches, then the corresponding coordinates read into the computer must also have the same dimension; another requirement was to have the data stored in a format consistent with the Intergraph System. This example shows that even in the United States, it is difficult to acquire an automated scan-input and reconstruction system for engineering drawings at a price of $30 million. For the time being, one must rely on manual techniques to re-define the drawings using interactive graphic systems. In China, research and development of a scan-input and vector data transformation system is also under way, and some encouraging results have been obtained.

Another new approach worth pursuing involves the application of image processing techniques to provide three-dimensional geometric data to create accurate computer models in a CAD system.

I. Brief Review

Most of the work done in China generally followed three different paths. The first is structural photography. In late 1985, Canadian Professor J. P. Duncan visited China where he introduced the Schlieren interferometry technique of measuring human limbs and faces, and the technique of using

digitally-controlled machine tools to manufacture artificial limbs, as well as his research work on three-dimensional graphics. The equipment required for the Schlieren interferometry technique can be produced domestically and are relatively inexpensive; however, their use has been limited to laboratories, and their accuracy is also limited. The second approach is laser ranging. This technique has been used by General Motors to measure the profile of a prototype automobile and then use the data to generate a model for the CAD system. This approach provides high accuracy, but it is rather expensive; also, it is not sufficiently mobile for field use. The third approach is stereo photography by matching two separate photographs of the same object. In 1982, the French Renault automobile factory used a special camera to construct a three-dimensional model of a prototype automobile by taking readings of the coordinates of corresponding points from two different photographs. They believe that in terms of protecting the secrets of a new design, the photography technique provides better security than a direct measurement system.

II. Development in China

We have applied the third method in constructing a model of test article which was the seat base-plate built by the Renault factory. It was a stamped aluminum plate with reinforced ridges and a large number of circular and semi-circular holes; the surface of the plate was painted. To produce this part domestically requires machining the stamping mold. Unfortunately, the drawings did not show the cross-sectional data of its external profile, and one cannot rely on measurements of the actual object because they did not meet drawing specifications. Therefore, it was necessary to superimpose the measured data onto the drawings and apply CAD techniques. In order to make this method as general as possible, we used a medium-range regular camera to take photographs of the same section of the object from two different locations; the distances between the cameras and the object were not recorded. To determine the camera locations, we first marked 8-10 target points on the object (at least 6 points) whose coordinates were accurately measured. In fact, by using an iterative technique, it is possible to calculate the camera locations and the relative dimensions of the object without pre-measuring the coordinates of the calibration points. Once the absolute distance between two arbitrary points on the object is known, then the shape and dimensions of the object is completely determined.

The two photographic negatives were processed by the System C-4500 digital scanner to produce two digital images which were recorded on magnetic tapes. The scan interval was chosen to be 25 μm, with 256 levels of gradation. The coordinates of the two calibration points on the two digital images were determined by the ARIES-II image processing system. These two tasks were accomplished using equipment from the National Measurement and Drawing Institute. The remaining tasks were carried out on the VAX-11/750 computer and the Tektronix 4115B graphics terminal of our own office.

The main difficulty in matching the images of a curved surface is to determine the relationship of two corresponding images of the same object point.

For each boundary line, a generalized optimization and search method is used to find all the image elements which make up this boundary; then the smallest rectangular window which can cover this boundary is determined. The existence region of the boundary is defined to be the larger dimension of the rectangular window. The continuous series of image elements located at the center of the boundary profile can be obtained by dividing the boundary into finer intervals. The series is then discretized by deleting every other image element. The remaining image elements are called the primary correlation points. The total number of correlation points determines the size of the boundary.

The existence regions can be divided into different groups according to their size. In this example there are two groups: the first group is 10-120, the second group is 120-700. The part of the boundary whose existence region is less than 10 is deleted. Matching is performed sequentially for the boundaries of the first group and the second group; and only points within the same group are matched. In the first group, no corresponding boundary is found; if its existence region is relatively large, then it is treated as part of the second group.

The following procedure is used to find the boundary in the second image which corresponds to the boundary E_j^1 in the first image: 1) select a candidate boundary using the internal limit curve; 2) determine the maximum correlation point of the main correlation element of E_j^1 in E_j^2 using the method of gradation correlation; 3) select the corresponding boundary of E_j^1 based on the results of point correlation.

By successively applying this matching procedure, it is possible to obtain a series of matched elements. However, the matching process is not completely automatic; sometimes human intervention is required, particularly in determining the limiting values.

Once the corresponding boundaries have been identified, the next step is to match the lateral and longitudinal fringes. The lateral fringes are extracted using 5 x 7 gradient operators, and the longitudinal fringes are extracted using 7 x 5 gradient operators. The difference between these operators and the boundary operators is that these gradients have both magnitude and sign. Correlation coefficients are determined only for those image elements on the same lateral or longitudinal fringes and with the same sign.

Once a set of corresponding image elements have been obtained, the coordinates of the corresponding object points can be determined based on the estimated camera locations; this data is then processed and smoothed to construct a simulated surface.

The total area covered by the two photographs is approximately 300 x 400 mm. Sample calculations show that the above method can measure contour points with a maximum error of 3.2 mm, an average error of 1.0 mm, and a maximum relative error of 0.8 percent.

Some parts of the measured object do not show significant variations in gradation; other parts have intense reflections; also, there is a large variation in camera angles. These factors cause difficulties in the matching process, and are the main sources of error. On the other hand, the high precision of scanned samples, the high measurement accuracy of camera calibration points (0.03-0.05 mm), and the effective matching process lead to small average error.

The above discussion illustrates the feasibility of constructing a three-dimensional computer model by reducing two photographs taken by ordinary cameras; this technique is of practical value and can potentially be used in many future applications. For example, in the development of instruments and gauges, we can establish a sample data base by taking photographs of reference materials displayed at foreign exhibits. The same method can also be used for architectural designs, mechanical products, and precious art objects. However, what we have discussed here is only the initial step; there is a great deal of work to be done to further develop this technique.

Past, Future of China's Space Technology Reviewed

40080138 Beijing HANGKONG ZHISHI [AEROSPACE KNOWLEDGE] in Chinese No 2, Feb 89 pp 8-9

[Article by Tu Shoue [1458 1343 6948]]

[Text] In the mid 1950's, in an effort to meet the needs of national defense, the Communist Party Central Committee and the State Council decided to develop China's missile industry, and established the No 5 Institute of the Ministry of National Defense. At that time, only a handful of people were involved, and there was no one (including Comrade Qian Xuesen [6929 1331 2773]) with missile experience. Nevertheless, from this humble beginning China's aerospace industry began to grow. Because of the high priority given by the party, the special concerns of Chairman Mao and Premier Zhou Enlai, and the general support from organizations around the country, the No 5 Institute grew rapidly, particularly when the Soviet Union withdrew their technical support in 1960. Unfortunately, for three consecutive years, China suffered severe natural disasters which left the country in great financial difficulty. Whether to continue missile development became a controversial topic. It had been reported that during a historic meeting at Bei Zai He, party members debated this issue for long hours, and finally Chairman Mao made the decision to continue missile development. Over the past 30 years, primarily due to the continuing support of the Communist Party and of organizations around the country, we have made significant progress in this area. In retrospect, the two major decisions of the Central Committee, i.e., to develop the atomic bomb and the missile, played an important role in enhancing China's position in the world.

During the initial phase of missile development, we did not realize the economic potential of this technology; we were overly concerned with security, and completely isolated ourselves from outside. No one (including most people in this country) knew about our work, and we were poorly informed about other developments. However, this situation changed after the 11th Party Congress; the party's emphasis had shifted in the direction of applying aerospace technology for economic development. The benefits

derived from aerospace research have commercial as well as military implications. The satellites we launched in recent years can potentially have significant economic payoffs. However, not everyone shares this view; some say that China is so poor because resources had been spent on developing the atomic bomb and the missile. They believe that we should follow Japan's course of development, i.e., first develop our economy to build up the nation's wealth, then consider developing the aerospace industry. However, they have no idea how much money was actually spent in developing the bomb and the missile, neither do they have access to the results of a payoff-to-cost analysis. Recently, this question was addressed in a speech given by Premier Li Peng at the 30th anniversary of the Defense Science and Engineering Commission: China spent very little money on these two projects; in fact, we spent the least amount compared to other countries on similar projects. It is my understanding that the total expenditure of the No 1 Institute of the Ministry of Astronautics Industry over the past 30 years is less than one half of the funds spent on the first phase of the Bao Gang engineering project. Initially, we simply did not consider the possibility of applying aerospace technology for economic development; specifically, I am speaking of communications satellites. We have launched two of our own communications satellites, yet the Central Television Station still rents foreign satellites, why? One reason is that we do not have a complete system of compatible receiving equipment; the other is that some people do not have confidence in our own products. This is very disturbing; because even if the reliability of our satellites is not as high as other country's, using our own satellites would provide the motivation for improvement. Recently, the Central Television Station decided to start using our own satellites. China's retrievable satellites can take photographs which are used by many different organizations. Some people have spent a great deal of money buying satellite pictures from abroad, but their quality is not necessarily better than our own pictures. The Central Television Station has agreed to supply photographs to various organizations such as water conservancy, mines, and railways sectors. Currently, it is the party Central Committee's policy to require that our high-technology research should serve the purpose of economic development. For example, communications satellites can be used in education by providing a nationwide electronic education network; the main question is how best to achieve this goal. The answer is that we scientists and engineers must do all we can to improve the existing system; at the same time, we must also try to gain the support of other organizations around the country.

Let us now review the history of our aerospace development for the past 30 years. In 1956, the party Central Committee held a science planning meeting and established a "12-year science development plan" which emphasized aeronautics and astronautics. On this basis the No 5 Institute of the Ministry of National Defense was organized. Initially, we tried to seek assistance from the Soviet Union, but their attitude was highly guarded, and the only assistance we received was the training of a few dozen college students. Under those conditions, Comrade Nei Rongqing drafted a guideline

for the institute: "Our primary goal should be to achieve self reliance; but we should try to get foreign assistance whenever possible, including the results of scientific research of capitalist countries." In 1957, the Soviet Union changed their attitude and offered to provide some technical assistance. As a result of negotiation between the Soviet Union and a Chinese delegation headed by Nei Rongqing, we were given several pieces of obsolete hardware, which included an R-2 surface-to-surface tactical missile, a surface-to-air missile, a surface-to-ship missile, and two aircraft: the MIG-21 and the TU-16. They also promised to deliver a prototype atomic bomb, but the promise was never kept. In fact, the information given to us was limited to manufacturing and operational information only; they did not release any design information. Also, we entered a technology purchase agreement with the Soviet Union where they would send technical advisers to this country to help us start a factory to manufacture copies of the missile. It was under these conditions that China's first aerospace team was organized into a working unit. When the Soviet advisers withdrew in 1960, the manufacturing of the R-2 missile copy had succeeded, but the liquid oxygen pump failed to meet design requirements. The Soviets insisted that we must use a Soviet-made pump, but they refused to sell it to us. As a consequence, the party Central Committee decided to develop the pump on our own, and continue to concentrate our efforts on completing the R-2 missile before initiating the design of a new model. On 5 November 1960, the first R-2 missile copy was successfully launched; this was followed by two other successful launches. Evidently, the Soviet Union's intention was not really sincere because their assistance was full of obstacles and restrictions; nevertheless, we succeeded on our own. It was on this foundation that we began designing our own missiles. Actually, even before the first R-2 launch, we had considered improving the R-2 missile to increase its range. In March 1963, the first test of this Chinese-designed missile launched from the Jiu Chuan Launch Site failed. Ten seconds after ignition, the engine caught fire, then the missile became unstable and fell to the ground. The reason for this failure was that we were concerned only with the individual missile components and failed to consider the missile from a system point of view. Therefore, we decided to stop and rethink our strategy; on the one hand we tried to improve our design, on the other hand we tried to incorporate as much as we could the scientific achievements of the capitalist countries. Two years later, on 29 June 1964, the redesigned short-range missile was successfully launched. During the same year, eight successive launch tests were conducted and everyone was a success. The lessons learned from developing the short-range missile represented an important step in the evolution of China's aerospace industry. From this experience, we gained a good understanding of how a missile should be designed and how to solve system problems. Having taken this initial step, we quickly proceeded to build and launch an intermediate-range missile in December 1966. In January 1970, an intermediate-long-range two-stage missile was launched. Finally, in September 1971, an intercontinental missile was successfully launched. This series of successful launches paved the way for future development of China's aerospace industry. In reviewing

the work we have done, we can attribute our success to the following factors: first was to insist on the policy of "self reliance" and continue to develop new missile models; second was to be persistent in carrying out our design goals without becoming discouraged by temporary setbacks; third was to have a comprehensive plan and to gain the support of the entire nation.

China's launch vehicles were developed on the basis of surface-to-surface missiles. Currently, there are four different launch vehicles. The "Long March-1" is an intermediate/long-range missile augmented with a solid stage. In 1971, it successfully launched the satellite "Dong Fang Hong-1" into orbit; later, it was also used to launch the "Xi Jian-1" satellite. The "Long March-2" was developed on the basis of an inter-continental missile, with its warhead replaced by a satellite. On 5 November 1974, its first launch failed. However, since 1975, it has had 11 successful launches. Another rocket which is similar to the "Long March-2" is the "Feng Bao-1," which was built in Shanghai and can carry three satellites into orbit in a single launch. The "Long March-3" is essentially a "Long March-2" rocket augmented with a hydrogen-oxygen stage. It has successfully launched two geostationary communications satellites; in December 1988, it will launch the third one. It has the capability of carrying a 1.4-ton payload to a transfer orbit. The "Long March-4" is a three-stage rocket, where the third stage carries conventional propellant. Recently, it was used to launch the "Feng Yun-1" weather satellite. These four launch vehicles have demonstrated China's satellite launch capability and have attracted considerable attention around the world.

Let us now talk about launch vehicles for the future. The "Long March-2" currently has a low-orbit payload capability of 2 tons; in addition to launching retrievable satellites, it can be modified to launch experimental equipment for micro-gravity and low-temperature experiments. A modified "Long March-2" can carry 300-500 kg [returned weight] of experimental equipment into orbit and continue operation for a week. At the present time, the only countries capable of launching retrievable satellites include the United States, the Soviet Union and China. Based on current assessment, the "Long March-3"'s transfer-orbit payload capability of 1.4 tons appears to be inadequate. The trend of communications satellite development in the 1990's is toward larger size; future geostationary satellites are expected to be in the range of 2.4-3.0 tons. Therefore, the thrust of the third stage of the "Long March-3" must be increased. By connecting the four thrust chambers of the hydrogen-oxygen engine in parallel, the vacuum thrust can be increased to 4.55 tons, which will boost the transfer-orbit payload capability from 1.4 tons to 2.5 tons. The next step would be to add a booster rocket to further increase the payload capability to 4.5 tons; this would provide greater capability than the Japanese H-2 and the European "Ariane-4." In order to meet the immediate needs of providing a launch vehicle for domestic use, we can consider adding four boosters to the "Long March-2" rocket. By increasing the number of first-stage engines from four to eight, it is possible to

increase the low-orbit payload capability to 8-8.8 tons; thus, this rocket can provide the launch capability of a space shuttle. This idea generated considerable interest in several foreign companies which had indicated their desire to enter a joint venture with us to launch their satellites. In the past, we have designed the rocket by customizing it for a particular satellite; obviously, this was very uneconomical. In the future, we must establish a system where all the hardware components are made interchangeable as much as possible; these would include the engine (which is half of the entire system), and the control system hardware such as computers and servo-mechanisms. For example, by strapping the third-stage of the "Long March-3" to a "Long March-2" rocket, it is possible to construct a large three-stage rocket which can carry a single payload of 4.5 tons or two smaller payloads in a transfer orbit. Through serialization of the launch vehicles, their reliability can be improved and their cost reduced, thus making them more competitive on the international and domestic markets. The future prospect of liquid-propellant rocket is also quite good because of its high specific thrust and its lower cost.

Aerospace is one of the eight critical areas of the nation's high-technology development plan. To develop our aerospace industry, we must study the design of large launch vehicles and space transportation systems as well as the deployment and use of space stations. On the issue of space transportation system, my personal view is that we should first clarify our goal on the space station because space shuttles are designed primarily to serve the space station. The United States is designing a large space station whose assembly requires 10 or more shuttle flights; clearly, this is not the course we should follow. The Soviet Union's space station is assembled from several modules which are based on technologies similar to those used by this country; we may be able to learn from their experience. Building a large launch vehicle requires the development of a high-thrust rocket engine. The new engine must use fuel which is inexpensive and non-toxic such as liquid oxygen, methane or ethane; in addition, a large hydrogen-oxygen engine must also be developed. Based on the experience of other countries in developing large launch vehicles, we should take advantage of the mature liquid-propellant engine technology as much as possible.

The main function of a space transportation system is to transport personnel and cargo to and from the space station. Today, there are two different approaches to the development of space transportation system; i.e., small spaceplanes with wings, and flying ships [i.e., shuttles]. My own view is we should pursue both approaches; in addition to developing a small flying ship, we should try to develop a small space plane with limited passenger and cargo capacity, similar to the European spaceplane, the "Hermes." However, there are many difficult problems associated with the development of spaceplanes. For example, one must solve the aerodynamic problems encountered in flying through a wide range of velocities: maximum velocity higher than Mach 20; transonic velocity during re-entry; and low velocity at landing.

In summary, to develop China's aerospace industry, we must have an overall plan for the immediate tasks and for future work. If the work is carried out properly, we should be successful by the year 2000. The Beijing Aeronautical and Astronautical University has been given the mission.

A Brief Resume of the Author:

Tu Shoue, a Chinese rocket expert, was born in Huzhou City, Zejiang Province on 5 December 1917, and graduated from Qinghua University in 1940. His positions include: chief engineer of the Ministry of Astronautics Industry, vice chairman of the science and technology commission, chairman of the science and technology committee of the research institute, deputy chairman of the second board of directors of the Chinese Aeronautical Society, and delegate of the Third National People's Congress. Over the past 30 years, Tu has organized and directed China's short-range missile programs, and been the chief designer of several of the Chinese-built intermediate-range rockets. He has also directed the research and development efforts and flight tests of China's launch vehicles. He has considerable experience in technical management and has made major contributions to China's rocket and missile development and to China's aerospace industry.

Details of Supersonic FT-7 Trainer Presented

40080151 Beijing HANGKONG ZHISHI [AEROSPACE KNOWLEDGE] in Chinese No 3, Mar 89, pp 8-9

[Article by Zhang Zhou [1728 3166]]

[Text] The FT-7 is a new supersonic trainer aircraft developed by the Guizhou Aviation Industrial Corporation; it is primarily used for flight training. Here, we shall present a brief description of the history, the unique features and the performance of this aircraft.

With the ever-improving flight performance and increasing complexity of equipment of combat aircraft, flight training has become more time-consuming and more sophisticated, and the cost of training has also increased considerably. In an effort to simplify flight training and reduce its cost, and make it possible for the pilot to acquire the skill to operate a modern advanced aircraft within a relatively short time, the Guizhou Aviation Industrial Corporation began developing the FT-7 aircraft in the late 1970's. The original goal was to develop an aircraft which not only could be used for flight training but also could be used in combat and attack roles.

As a result of the combined efforts of engineers and technicians, the first prototype was developed and successfully test-flown in 1985. The FT-7 aircraft has an air-inlet located in the nose section, a delta wing design, a serial twin-seat cockpit, and forward tricycle type landing gears; the fuselage is a metallic semi-rigid shell structure. The forward fuselage is made of a hard-shell structure because its cover skin is subject to very high loads. As the rear fuselage is subject to high temperatures generated by the powerplant, it is made of titanium alloy, which is superior to both aluminum alloy and stainless steel in terms of strength, endurance, corrosion resistance and heat resistance.

The powerplant of the FT-7 is the WP-7BM engine with a thrust of 6,100 kg; it is produced by the Li Yang Co. which is a subsidiary of the Guizhou Aviation Industrial Corporation. This engine has good stability and controllability during aircraft maneuvers and weapon firings.

Because of the added rear seat, a fuel tank is installed between the rear seat and the vertical tail to compensate for displaced fuel. Both the front and rear seats are raised by an appropriate amount to improve the pilot's visibility.

Below the fuselage are two ventral strakes designed to provide directional stability under high-Mach-number conditions. Test results show that these strakes have many desirable features such as aerodynamic efficiency, high structural strength, and low weight.

The pitot tube is located at the upper right corner of the nose section. The airborne equipment on the FT-7 include a radio transmitter, a radio compass (with dual control box), a flight parameter recorder, and an intercom.

An important design issue of a new trainer aircraft is the cockpit configuration. In the following paragraph, we shall discuss the cockpit design and the interior equipment and layout of the FT-7.

The cockpit of the FT-7 aircraft has a tandem seat design: the forward seat compartment is for the student and the rear seat compartment is for the instructor. The canopies open to the right, each cover has four lock rings, and a sealing belt is installed around the cockpit opening. When the covers are closed, the sealing belt is inflated to seal the cockpit.

The canopy is made of high-grade glass material which has a high degree of transparency and light fastness; it is also impact-resistent and has high tensile strength; the windshield is made of a multi-layered bullet-proof glass material. An advanced soft connecting structure is used to attach the glass to the frame. To provide flight safety during landing, the rear seat compartment is equipped with a forward periscope to give the instructor a clear view of the runway beyond 25 meters. The opening and closing of the periscope are linked to the operation of the landing gear; i.e., the periscope is opened when the landing gear is deployed, and closed when the landing gear is retracted.

The FT-7 aircraft has an advanced air-conditioning system. The temperature inside the cockpit can be automatically controlled over a wide range of flight altitudes and seasonal variations to provide a good working environment for the pilot.

As part of the life preservation system, both the front and rear cockpits of the FT-7 are equipped with rocket-propelled ejection seats. Because of the twin-seat design, the safety problem of ejecting both flyers in case of an emergency must be considered. In order to prevent the two pilots from interfering with each other, the FT-7 uses the following ejection sequence: "discarding the rear canopy---ejecting the rear seat---delay 0.4 sec---discarding the forward canopy---ejecting the front seat". Of course, it also possible to eject only one seat at a time. Once the ejection system is activated, the entire ejection sequence is automatically carried out to completion.

In order to improve the pilot's ability to respond to instrument malfunctions in case of an emergency, the FT-7 is equipped with a "malfunction simulation system". This system has a control box in the rear seat compartment which can be operated by the instructor. Specifically, the instructor can intentionally create artificial "malfunctions" in the integrated magnetic

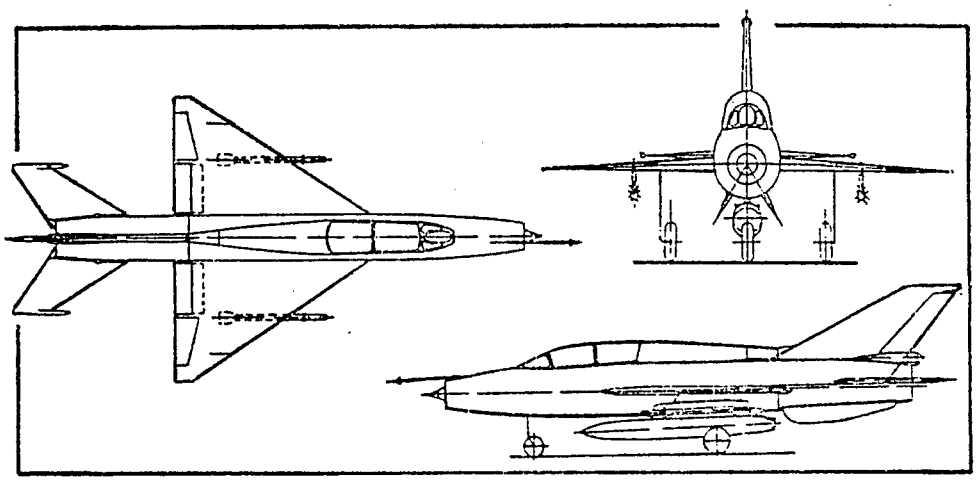
compass, the radio compass indicator, the horizon gauge, the pitot tube indicator, the vertical speed indicator, the atmospheric pressure indicator to test the student's ability in handling the problem. Results indicate that this system provides an effective means of improving the pilot's skills. In addition, the FT-7 is also equipped with cut-off or disable mechanisms in the engine control, flight control, and the baking systems; if the student makes an error in these systems, the instructor can take action to either nullify or correct the error. For this reason, several systems are equipped with dual displays, dual indicators, dual controls or dual converters, and with additional oxygen bottles and cold-air bottles.

Because of the large number of instruments and indicator lights in the cockpit of the FT-7, it is a design requirement that the cockpit must be properly illuminated for the pilot to operate the controls; also, illumination of the front and rear compartments must be coordinated so they do not interfere with each other. The illumination system of the FT-7 uses the red-light illumination technology developed in this country. It has two illumination states: primary illumination state and emergency illumination state. To ensure its reliability, each illumination panel contains two or more lights which are powered by two independent electric circuits. The power supply circuits for the front and rear cockpits, the control console, and the instrument panel are all separately controlled.

Key Technical Data of the FT-7 Aircraft

length	14.874 m
wing span	7.154 m
height	4.103 m
normal take-off weight (with 2,380 liters of fuel)	7590 kg
maximum indicator speed	1100 km/hr
maximum level-flight speed	M > 2
minimum level-flight speed	215 km/hr
minimum dynamic speed	350 km/hr
service ceiling	17,300 m
turning radius	less than 2,200 m
maximum range	1,300 km
endurance	1 hr
take-off speed (full power)	315-335 km/hr
take-off distance (full power)	900-1100 m
landing speed	305-325 km/hr
landing distance	850-1,100 m
rescue altitude range	0-ceiling
maximum operating overload	7 g

Three Views of the FT-7 Supersonic Trainer Aircraft.



Studies of Relationship Between Heat Treatment, Martensitic Transformation Temperatures of t-Precipitates in Mg-PSZ Ceramics

40090049a Beijing GUISUANYAN XUEBAO [JOURNAL OF THE CHINESE CERAMICS SOCIETY] in Chinese Vol 17 No 1, Feb 89 pp 8-12

[English abstract of article by Yuan Qiming [5913 0796 2494], et al., of the Department of Materials Science and Engineering, Tianjin University]

[Text] The relationship between heat treatment conditions and martensitic transformation temperatures (M_s, M_f), as well as the transformable fraction of t-ZrO_2 precipitates in Mg-PSZ ceramics containing 10 mol percent MgO, is studied in this paper. It is assumed that the particle size of the t-ZrO_2 precipitates and the stress-strain state developed during heat treatment are two fundamental factors determining or affecting the martensitic transformation temperatures and the volume fraction of the stress-induced transformable t-ZrO_2.

Heat treatment at both 1420°C and 1100°C is better for controlling M_s and M_f than simply treating at either 1420°C or 1100°C, yielding a higher volume fraction of transformable t-ZrO_2 precipitates, and, therefore, is a promising new heat treatment technique which will optimize the structure and properties of the Mg-PSZ ceramics. At the low temperature end of the "Δl-T" curve of the Mg-PSZ specimen treated at 1100°C for 4 hours, there was no pronounced expansion effect characterizing martensitic transformation.

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Study of Application of Pattern Recognition to Perovskite Oxide Superconductors

40090049b Beijing GUISUANYAN XUEBAO [JOURNAL OF THE CHINESE CERAMICS SOCIETY] in Chinese Vol 17 No 1, Feb 89 pp 13-17

[English abstract of article by Wen Yuankai [3306 0337 0418] of the Department of Applied Chemistry, University of Science and Technology of China; Liu Hongbo [2692 1347 3134], et al., of the Department of Physics, Xinjiang Normal University; Nie Shengzhe [5119 5110 0772], et al., of the Department of Chemistry, Anhui University]

[Text] Since the single-phase $YBa_2Cu_3O_{7-y}$ has a perovskite structure, compounds exhibiting the perovskite structure can be expected to be high temperature superconductive materials. In this paper, by means of pattern recognition, the authors have studied the quaternary oxide compounds and fluoride compounds exhibiting the perovskite structure, thereby predicting many possible high T_c superconductors. The superconductive mechanism is discussed using the characteristics of six bond parameters.

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Study of Mechanism of PTC Effect in Semiconducting Ceramic $BaTiO_3$

40090049c Beijing GUISUANYAN XUEBAO [JOURNAL OF THE CHINESE CERAMICS SOCIETY] in Chinese Vol 17 No 1, Feb 89 pp 53-58

[English abstract of article by Feng Shiming [7458 1102 2494], et al., of Nanjing Institute of Chemical Technology]

[Text] Auger electron spectroscopy (AES) for the PTC thermistor specimens of different resistivities was observed. The results show that the semiconductivities of $BaTiO_3$ ceramics originate from the valency change of the element Ti:$Ti^{4+}+e \rightarrow Ti^{3+}$, and the ratios of the Ti auger triplet at about 382, 416 and 450 eV depend markedly on the semiconducting level of the materials.

The valency of acceptor-doped impurities, such as Cu and Mn, and its change in PTC materials with a change in temperature were examined by electron spin resonance (ESR). According to the experimental results and measurements, a new concept involving the interface acceptor state is proposed, i.e., various interface acceptor states (e.g., oxygen absorption, barium vacancies and oxidized impurities, etc.) may exist alone or together, depending on the composition and technology of the PTC materials.

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Development in Rice Hybridization, Gene Banks, Cattle Breeding

40081029 Beijing XIANDAIHUA [MODERNIZATION] in Chinese No 2, Feb 89 pp 8-9

[Article by Chen Zujia [7115 4371 3946]]

[Excerpts] [Passage omitted] A key aspect of the biological research included in China's high-technology development plan (termed the 863 Plan) is to cultivate the highly productive, superior quality and adversity-resistant new varieties of plants and animals. In this area research personnel have utilized advanced, modern biotechnology to integrate genetic engineering, cytotechnology and conventional breeding methods to blaze new routes for agriculture. [passage omitted]

Realization of the Two-Line Method of Rice Hybridization

China's rice hybridization technology occupies a leading position internationally. The exploitation of the advantages of hybridization to greatly increase rice yield has already become reality. The problem is in the difficulty of stabilizing the hybrid advantages of the current Indica hybrid rice strain. A method embodying a complementary set of three lines (a sterile line, a restorer line and a maintaining line) must be adopted and seed production carried out every year, otherwise, degeneration will occur. Obviously this technique is a great deal of trouble. For example, in 1988 due to the effect of abnormal weather on hybrid rice seed production, the seed price rose which had an extreme negative effect on grain production levels. Scientists are constantly working hard to find a simple and convenient means of producing hybrid rice.

In 1973, a scientist by the name of Shi Mingsong discovered that certain types of rice contain a photosensitive nucleus sterile gene. Due to the existence of this type of gene, long exposure to the sun and warm weather can cause the rice to become a male-sterile strain. This is to say that the rice of one strain can fulfill two functions, i.e., the function of the sterile line and that of the maintaining line. Therein rests the possibility of changing the three-line method into a two-line method. Researchers of the 863 Plan have already developed a number of stable photosensitive nucleus sterile strains suited to local climatic conditions, among which are included Japonica and Indica rice. [passage omitted]

Genetics tells us that the more distant the relationship of the plants the greater the usable hybrid advantages and the stronger the progeny. Therefore, scientists conceived not only of crosses between varieties of Indica rice, but also between the two subspecies Japonica and Indica to fully exploit the advantages arising from distant relationships. The difficulty in hybridizing subspecies is primarily in the fact that their genes do not readily combine, thereby reducing fertility rates. Higher organisms all possess this kind of exclusivity. A gene with broad affinity, discovered by a Japanese scientist, has facilitated the hybridization of subspecies. Under arrangements of the 863 Plan, in 1988 the function of two types of genes was utilized to carry out crosses between subspecies of rice. After testing on small areas in many locations the yield of the Indica-Japonica rice hybridized by the two-strain method was more than 20 percent higher than that of the rice hybridized by the three-strain method. Scientists estimate that in roughly 3 to 5 years, use of this new hybrid rice could be expanded to large fields.

So as to increase rice yield, scientists are also working on improving the plant's photosynthetic capacity. They have discovered that in carrying out photosynthesis, higher plants are primarily fixing carbon dioxide. In this process an oxidase called diphosphoric acid carboxylase plays a key role. The diphosphoric acid carboxylase is composed of eight large subunits and eight small subunits. After a year's work, research personnel separated the large and small subunits and artificially synthesized the genes for the small subunits. Then they recombined them to form a new generation of diphosphoric acid carboxylase. The carbon dioxide fixing capacity of the transformed enzyme is greatly improved. The success of China's researchers has received international attention and acclaim in the field.

Also worthy of mention is that researchers have already isolated some bacilli from soil, air and the surface of rice leaves. A protein secreted by this type of bacillus can kill the bacterial pathogen of the bacterial blight of rice and has an inhibiting effect on bacterial wilt of potatoes and cabbage soft rot. It is commonly known that bacterial blight disease is one of the greatest threats to rice production. Most areas in China will lose 10 percent of rice production due to this disease. If through genetic engineering, the genes of this type of bacillus are implanted in rice, a plant resistant to bacterial blight disease can be produced. This has great significance for increasing rice output.

Establish a Gene Bank

Genetic engineering in essence is the extraction of genes from organisms and the transformation and storage of genes for the purpose of improving the nutritional content or disease and parasite resistance of organisms. For example, should a certain crop lack resistance to a certain disease an appropriate gene must be sought out from other plants or even from microorganisms. Within a period of time, if such a gene can not be found it can be synthesized artificially. It can then be implanted in the crop, much like giving a vaccination to people in order to increase resistance to smallpox. That crop will then possess a natural ability to resist the disease. If the extracted

gene can not be used at once or used entirely then it can be placed in storage, much like placing purchased books in storage at a library. This facilitates use whenever needed. This kind of storage is called a gene bank.

The researchers of the 863 Plan have put considerable effort into this area. They have obtained soybean protein gene and synthesized genes for higher nutritional value and a gene resistant to bacterial disease. From bacteria they have obtained a gene which provides plants with resistance to pests and they have established many types of gene banks. In 1987, the United States first obtained a virus-resistant tobacco plant possessing the protein coat gene of tobacco mosaic virus. China's researchers successfully cultivated this plant in 1988. This also is at the forefront of world research.

Apart from this, researchers in China have also implanted genetic material from external sources into protoplasts and cultivated plants from them. For a long period of time the difficulties of regenerating grain protoplasts have been extremely great. In 1988 China's researchers made some headway. Having succeeded in producing corn and rice plants from protoplasts, wheat plants were also successfully cultivated, which put China in a leading position worldwide.

Can Seeds Be Created Artificially?

Plant reproduction must depend upon seeds. The embryo inside the seed is the basis of plant reproduction. If the embryo is damaged, this is what is often called by farmers "planting in vain." It is difficult to conceive of depending on it to sprout. This is common knowledge, while genetic engineering tells people that without an embryo a plant can be produced just the same. This represents a new way in which mankind can accelerate plant reproduction. Scientists obtain the somatic cells of a plant and carry out cultivation causing them to become somatic cell embryos. Then, much like wrapping meat dumplings, they are encased in a medium and on the outside are covered with a layer of artificial skin. In this manner an artificial seed is created.

The 863 Plan researchers have attempted this, preparing alfalfa, carrot and other artificial seeds. This work is very valuable with respect to accelerating reproduction and fixing hybrid advantages. However, scientists consider this work at present to be far from perfected. It is necessary to use several types of relatively easily studied plants as materials to gradually perfect the techniques for creating artificial seeds.

Research on Nitrogen Fixing by Plants

Nitrogen fixing by plants is a topic of common interest to the world scientific community. Were the nitrogen fixing capability of leguminous crops to be transferred to non-leguminous plants, the shortage of chemical fertilizer would be remedied, the cost of agriculture lowered and environmental pollution reduced. S&T personnel have carried out research on root nodules and confirmed that the formation of nodules is the result of the interaction of

nodule bacteria (rhizobium) and plant genes. Plants secrete a material known as flavonoid which like releasing a signal spurs activation of the rhizobium's nodule formation gene. Root nodules are precisely the result of expression of this kind of activated root nodule gene. Understanding this result provides man with a possibility, i.e., to adjust and control the activation function of the root nodule gene according to human needs. In those plants where nodule growth is required its activation would be triggered. Researchers have also discovered through experimentation a new protein which can control expression of the nodule formation gene.

Research personnel have observed that an oxygen sensitive gene exists in the rapid generation type soybean rhizobium which controls expression of the nitrogen fixing gene. This type of rhizobium was isolated from soil from the outskirts of Shanghai and is unique to China. Soybeans throughout the world can only effectively form nodules and fix nitrogen when infected with the slow generation type of soybean rhizobium. China has also observed that rapid generation type soybean rhizobium, due to the role of oxygen, control fluctuations in nitrogen fixing capacity. This has major scientific significance for research into artificial nitrogen fixing.

New Methods for Rapid Breeding of Milk Cows

As people improve nutrition and change their dietary structure they frequently can not get away from milk. In general the butterfat content of water buffalo milk is twice as high as that of ordinary dairy cows. If China, soon to have one-quarter of the world's buffalo, were to convert all the water buffalo used as beasts of burden into dairy cattle another important route for the development of a milk industry in China would be added.

However, dairy cattle as mammals have a gestation period of about 10 months and females generally have an ovulation period of 21 days. This creates difficulties for the large-scale breeding of dairy cattle. Today, frozen semen and in vitro insemination techniques are often adopted to increase dairy cattle insemination rates, but the limitations imposed by the dairy cattle ovulation period are still present. If the females do not ovulate, in vitro artificial insemination can not be carried out. Scientists have adopted two new methods to accelerate dairy cattle breeding. One method is the simple, fast and highly effective embryo separation technique. During development of a fertilized egg and emergence of cell division scientists use a small glass needle under a magnification microscope to separate two cells with extreme care. Then these half embryos are implanted in the bodies of female cattle, causing them to develop into calves. Each division of a single embryo requires about 2 to 5 minutes. This is a low cost, easily accomplished technique, a very effective method for tapping the advantageous genetic potential of the female animals and doubling the efficiency of embryo transplantation. As of 1988 researchers in China had already completed 200 dairy cattle embryo separation procedures.

Yet another method is to extract the ovaries of quality dairy cattle about to be slaughtered and carry out cultivation. Generally, from the body of one select dairy cow over 100 relatively good quality oocytes can be

extracted. After cultivation these oocytes are artificially inseminated and gradually develop into embryos. Then they are reimplanted in the body of a cow. In this manner one highly productive, high quality dairy cow produces not a single embryo, but over 100. This technique, similar to "killing the hen to get the eggs" has accelerated the breeding of dairy cattle. This field has very good portents for the future. Will 1989 produce a calf through the cultivation of an oocyte? The reader will have to await the good news.

Description of SLONN: a Language for Simulating Neural Networks

40080101b Beijing JISUANJI XUEBAO [CHINESE JOURNAL OF COMPUTERS] in Chinese Vol 11 No 12, Dec 88 pp 741-49

[Article by Xu Zhuoqun [6079 0587 5028], Beijing University, and Wang Deliang [3769 1795 0081], Institute of Computing Technology, Chinese Academy of Sciences: "SLONN: A Simulation Language for Neural Nets, and Its Implementation"; manuscript received 27 August 1987]

[Text] Based upon detailed research in the general nature of biological neuron networks, this paper proposes and implements a general-purpose descriptive language, SLONN, for neural networks. Using the methods of setting parameters and introducing forking to describe the interconnection modes of neurons, and by using declarations such as repeated connections, module types, and module arrays, all of which are used to describe large networks, we can thus allow the SLONN language to conveniently and effectively provide descriptions of large and small neural networks, as well as to carry out simulation experiments on these networks. The SLONN language provides an effective tool for neural network simulation on computer, as well as for research in artificial intelligence.

1. Overall View

The neural network that connects neurons is the fundamental structure of the brain, and is the basis of intellectual activity. Difficulties in conducting biological experiments on larger neural networks and the demand of artificial intelligence have brought about research into neural-network control theory simultaneously with experimental research on the brain.

Research on control theory for neural networks has grown rapidly in recent years. There is much research in progress with different animal subjects, everything from small neural network theory and data processing models for various receptors to small brain models. Despite the varied types of neural network behavior manifest in this research, and the fact that the goals of the simulators have not all been alike, the structural foundation they share is the neural network composed of neurons, where only the scale of the network and the method of organization differ.

In this paper, we present a high-level neural-network simulation language called SLONN. This general-purpose high-level language acts as a tool that

can lighten the amount of work in setting up neural networks on computers and in obtaining data from various simulation experiments, thus allowing the researcher to concentrate on studying effective logical networks. In addition, having a tool such as this also makes for easier exchanges among experts engaged in neural simulation.

This paper is a continuation of the paper "A Neuron Model for Use in Computer Simulation of Neural Nets" [published in Beijing ZIDONGHUA XUEBAO [ACTA AUTOMATICA SINICA] in Chinese Vol 14 No 6, Nov 88, pp 424-430; translated in JPRS-CST-89-007, 17 Mar 89, pp 55-64]. Details of the relevant neuron model are given in that paper.

II. Describing Neuron Networks

A. The SLONN language provides two descriptive methods for a single neuron:

1. It provides a standard neuron type (written as **neur**). What we mean by a standard neuron type is that all missing values for parameters of neurons will be automatically supplied by the system.

2. It allows a user-defined neuron type (which name is preceded by **neuron**). The user can define the type name for the neuron and can assign special parameter values. For example,

```
neuron
ptype (E=20)          ptype is the neuron type where the
                      resting potential E is 20 mv
... ...

ptype pear            pear is a neuron of the ptype category
```

After the word '**neuron**,' the user declares his own defined neuron type. In the network description that follows, the neurons in the network will be additionally declared with their corresponding type.

B. Forking and repeated connections

Figure 1 shows a simple neuron network. The neuron name is contained within a circle, a triangle indicates contact, numbers at the side are the intensity of connection, and single lines represent nerve fiber connections.

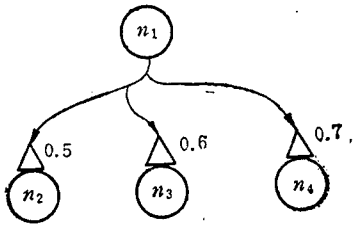


Figure 1. A Neural Network Example

The definition of a neural network in SLONN consists of two steps. The first step is to define the mode of connection, which is described as a **fork**. For the connection mode:

fork 3 (**to** 0.5, 0.6, 0.7): triple;

the number 3 that is closest to **fork** indicates a three-tined fork; **to** represents the direction of connection, its opposite being **from**. **triple** is the name of the connection mode type, the connection mode for which is shown in Figure 2.

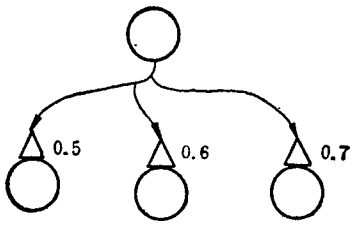


Figure 2. The Manner of a triple Connection

The second step is to join the name of the neuron with the defined **fork** type triple, consequently forming a neural network. For example:

triple (n_1; n_2, n_3, n_4);

which means: n_1 is the neuron produced; n_2, n_3, n_4 are the receiving neurons; the degree of connection (i.e., the degree of contact) from n_1 to n_2, n_3, n_4 is 0.5, 0.6, and 0.7, respectively (as determined by the triple connection mode); the issuing neuron and the receiving neurons are separated by a semicolon. The expression just used describes the network of Figure 1.

triple can be used several times as a type. For example: triple (g_1; g_2, g_3, g_4) describes the network of Figure 3.

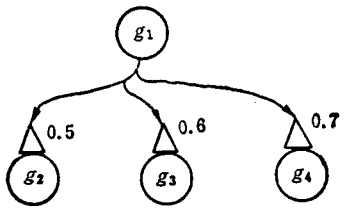


Figure 3. triple (g_1; g_2, g_3, g_4)

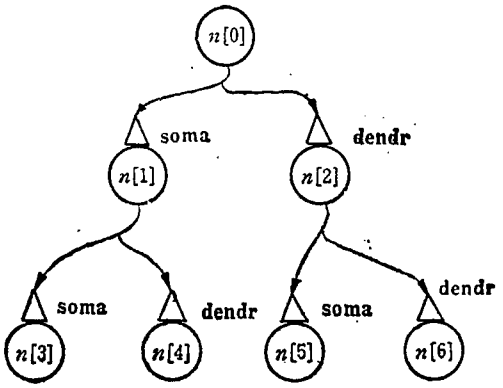


Figure 4. A Neural Network

If we want to use similar forks to do multiple connections, we would repeatedly use these forks. To more conveniently achieve this goal, SLONN provides the repeating connection **for** statement.

For example, the network of Figure 4 can be described with the following routine.

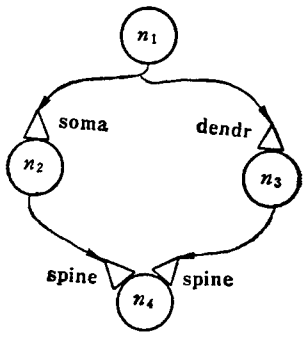
```
integer i;                          i is an integer
neur n[7];                          n[7] is an array declaration,
fork 2(to soma, dendr); beta;       which declares the 7 neurons
i=(0) for 2)                        from n[0] to n[6]
  beta (n[i]; n[2i}1], n[2i+2]);
```

The repetition statement, that is, the **for** statement, represents the fact that beta is to be used three times, and i is successively 0, 1, and 2. The repetition statement provides an effective descriptive tool for the regular interconnected network. **soma** and **dendr** that appear in the **fork** statement, together with **spine**, which will appear below, are the system standard connection intensities, which respectively indicate axial-body, axial-dendron, and axial-spine (where 'body' refers to nerve cell body, 'tree' refers to the dendron, and 'spine' to the gemmule).

C. Module type

If a particular sub-net must be repeatedly used in a network definition, this sub-net can be abstracted as a module (**module**) type.

The sub-net in Figure 5 is of a multiply appearing structure, which we can then abstract as a module. That would be written as follows:




```
module spade
{
  neur n1, n2, n3, n4;
  fork 2(to soma, dendr); alpha;
  fork 1(to spine); omega;
  inner
      alpha (n1; n2, n3);
      omega (n2; n4);
      omega (n3; n4);
}
```

Figure 5. The spade Module Type

spade is the name of a module type, which is composed of four neurons. What are declared beneath **inner** are connections that belong within the module.

If a user has three spade-module-type sub-nets snet1, snet2, and snet3, that would be declared as follows:

```
spade snet 1, snet 2, and snet 3;
```

Module types can quite naturally express the kind of basic structure of a nerve system is that of the cortex column.[2]

D. Module arrays

A module array is a group of modules arranged in an array mode. There are some special methods by which SLONN handles module arrays, which then allows module arrays to become effective means of declaring large neural networks. These methods are:

1. The connections among the modules within the array (external connections) need not be declared by the user.

2. When the system is completing the connections, it automatically deletes those single lines that do not point toward any neuron. For example, the network declaration for Figure 6 is:

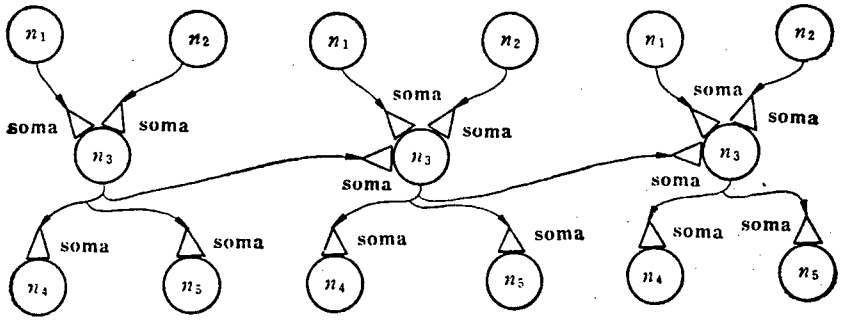


Figure 6. network[3]

```
module star
{
  neur n1, n2, n3, n4, n5;
  fork 1(to soma): alpha;
  fork 2(to soma): beta;
  right
```

this statement is an abbreviated expression of **fork** 2 (**to soma**, **soma**): beta

```
        alpha (n3; n3);

    inner

        alpha (n1; n3);

        alpha (n2; n3);

        beta (n3; n4, n3);

}
  ...   ...

star network [3];

  ...   ...
```

Here, **right** represents the directions of the external connections among the modules, i.e., to the right. In addition to **right**, SLONN also provides the connection directions of **left**, **front**, **hind**, **above**, and **below**, which are these directions for one-dimensional arrays, and the corresponding external connection directions are: **right** and **left**; for two-dimensional arrays, the corresponding connection directions are: **right**, **left**, **front**, and **hind**; for three-dimensional arrays, the corresponding connection directions are: **right**, **left**, **front**, **above**, and **below**.

network [3] is a one-dimensional module array composed of three star-shaped modules.

In SLONN, the dimensionality of module arrays is less than or equal to three dimensions.

E. Entering descriptions

For entering neutral networks, we use receptor neurons to represent various particular receptors. Receptor neurons are those neurons in a network that directly receive external stimuli. User definitions or programming can be used to simulate how the external stimuli (such as light signals) can be transformed into pulse-release alignments with particular frequency characteristics.

The pulse-release sequences for the receptor neurons are identified by the 0, 1 sequence, where 0 represents an absence of released pulse, and 1 represents a released pulsed. There are two ways to refer to release sequences for system-regulated beats:

1. The user directly defines the input module. For example:

```
neur neu;
string input;              input represents a string of stimuli.
input = {00111001}
stimulate (new ← input);   this is the stimulus statement.
```

The stimulus statement appends the string input to the receptor neuro neu. In accordance with system beats, the release sequence for neu can be figuratively expressed as:

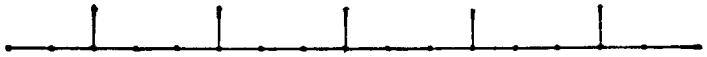
neu: 

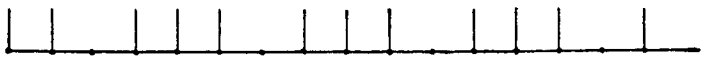
The smallest time interval is determined by the system.

Another example:

```
neur neu1, neu2;

string schema1, schema2;

schema1 = {0 0 1};

schema2 = {1 1 0 1};

stimulate (neu1 ← schema1:  5; neu2 ← schema2: 4);
```

which repeatedly appends the string schema1 five times to neu1, and the string schema2 four times to neu2. Within 16 beats, the release sequences for neu1 and neu2, respectively, are:

neu1: 

neu2: 

2. Defining release patterns with functions

At times, the user requires that rules for the intervals at which the pulses arrive fulfill a particular function distribution. This is widely used to simulate self-releasing electrical phenomena and the conversion of various receptors in response to external stimuli. SLONN provides a group of function definitions for random release sequences. Among these are equal distribution, exponential distribution (the Poisson process), normal distribution, and beta distribution. For example:

```
neur n1,
string input;
input = poisson (0.25);
stimulate (n1 ← input);
```

The upper portion shows that the release sequence of the receptor neuron$_1$ reaches a poisson distribution at a rate of 0.25 (i.e., on the average there is one release per four system beats).

III. Experimental Operations With Neural Networks

A. Run initialization. This makes each neuron in a network begin acting in accordance with the computer model. The neurons in the network should be operating in parallel. The network running dispatch algorithm in the SLONN language (see implementation methods in part IV) ensures that within each system beat all neurons move once, so each system beat thus simulates the interval between two neuron pulses in successive release (as for example 2 milliseconds). During actual execution on the computer, system beat times will depend upon the scale of the network.

B. Observation of results. The user can observe on the terminal the release sequence (the 0,1 string) for a group of neurons, and can also plot out neuron-release sequences together with changes in membrane potential.

C. Probing within the network. One can use specific statements to display and plot neural networks. The user can assign which neurons among them are to be so handled, and can use probe statements to obtain relevant information among the following: the intensity of contact of neuron contacts, the current memory value of a memory contact, and other neuron parameters and release frequencies.

D. Time skipping. This is used to speed up simulation of long-term memory. For this purpose, the SLONN language introduces time skipping statements, where the neural network simulates the forgetting mechanism in accordance with the given skip time, which changes the memory values of memory neuron contacts (the neural networks for this time must be in a quiet state).

E. Multiple runs. Two experimental preparatory statements are provided. The reset statement allows the neural network that has changed state in the previous run to recover the state before its first run. The initiate statement then preserves the network state of the previous run, at the same time making preparations for the next run and a newly entered release sequence.

Generally speaking, experimental operations for a network can be done in two modes of operation. One is the programmed mode, where experimental operations are entered into a program; and the other mode is the command mode, where the user uses a group of experimental operations commands to intervene in network runs, but these are definitely not entered into the program. At present, the SLONN system only provides the programmed mode.

We present below a debugged example (node selection), which program is used to simulate the behavior of [the genus] Aplysia.

```
net
{
    neur skin, sen1, sen2, intn;
    neur fint1, fint2, head, mov1, mov2, jaw;
    fork 2 (to 0.55): branch;
      ...    ...
    branch (skin; sen1, sen2);
      ...    ...
}
```

```
begin
    string touch, train;
    touch = {0 0 1 1 1 0 0};
    train = {0 0 1 0 1 1 1};
          /* expr1: a jaw-shrinking reflex */
    stimulate (skin ← touch: 12; head ← {0});
    display (4; jaw);    /* this statement indicates displaying the result,
                            and number 4 means from plotter */
    simulate (80);       /* this statement initiate simulating process. */
       /* expr2: training for short-term memory */
    stimulate (skin ← train: 9; head ← {0});
    simulate (63);
    stimulate (skin ← touch: 12; head ← {0});
    display (4; jaw);
    simulate (80);
      ...    ...
end
```

IV. Implementation Methods

The interpretation execution system of the SLONN language is written in the C language and uses the UNIX operating system. For syntax checking, which includes lexical analysis and syntax analysis, the Unix tools LEX and YACC are used.

In the process of network simulation execution, at each system beat, the system interpretive executor will scan all neurons, and will do a calculation of each neuron. It is worth pointing out that the scanning sequence for each neuron will generate a certain response for each run result, as shown for the network in Figure 7, where 10 neurons are interconnected (for purposes of discussion, the network has been drawn as directed graphs), and n_1 and n_2 are receptor neurons. It is quite evident that the precedence of calculation for n_1 and n_2 is important: calculation of n_1 depends upon the output of n_2 at the same system beat, while the contrary is not true.

To rationally arrange the scanning sequence, we must build the neural-network running sequence table exlist. We can use the following building algorithms, as well as neuron date tables, receptor neuron tables, and neuron data tables, receptor neuron tables, and network interconnection data, to generate the exlist table.

The building algorithms for the exlist table are as follows:

1. All neurons will be arranged in ascending order in accordance with their distance from a receptor neuron (we will call it "input distance"). By the

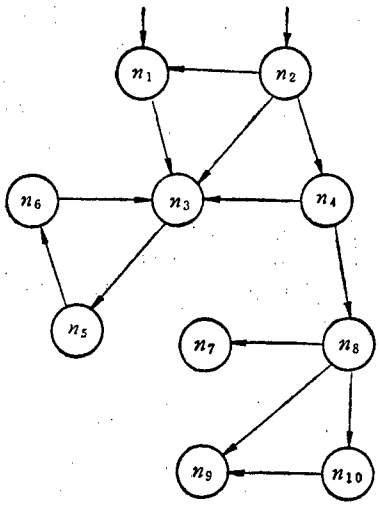


Figure 7. Directed Graph of a Neural Network

distance from neuron A to B, we mean the shortest distance of all the paths from A to B, that is, the number of sides of the smallest path for a directional side.

2. Calculate the lead-in degree. We define the lead-in degree of a neuron N to be the number of all neurons that satisfy the following conditions (they are called lead-in neurons): they have a side pointing to N, and also, their input distance is not less than the input distance of neuron N.

3. Sequentially arrange in ascending order by size of lead-in degree all neurons with the same input distance, and if the lead-in degree is also the same, then arrange them naturally. This builds exlist.

The exlist built for the network in the diagram above using this algorithm is: $n_2n_1n_4n_3n_8n_5n_7n_{10}n_6n_9$.

The goal of the dispatching algorithm is that in situations where delays in transmission times of pulses between neurons are not considered, that before we calculate a neuron, to the greatest extent possible, the output of all lead-in neurons within a particular beat will have been formed. Because we allow there to be links within the neural network, there is therefore no algorithm that will enable the output of all lead-in neurons to be generated when calculating any individual neuron. At present, the exlist algorithm is only one application algorithm.

Whether there will be an obvious effect of the running sequence on the entire behavior of the system is a problem that needs further study. In our observation, this kind of response may be ignored.

Among routine written in the SLONN language, the simulate statement serves to initiate network operations. When the system executes this statement it first uses the exlist building algorithm to generate the exlist table

(before the simulate statement, the system has built the various data tables for this neural network). Thereafter, with each system beat each neuron is calculated sequentially according to the exlist order, then it calculates the time totals, space totals, and threshold function. Then, it generates the relevant neuron output-input transmissions in accordance with the program description of the interconnections. The simulate statement will repeat over several system beats, and the number of beat repetitions is determined by the number of beats provided in this statement.

V. Conclusion

From the language point of view, SLONN is a language for describing a network, although that description is of a special network--a neural network. If we compare it to the SPICE language[3] for describing circuit networks, the Occam language for describing process communications,[4] and the BOSS system for describing large neural networks,[5,6] we discover that SLONN has two obvious characteristics:

A. SLONN introduces forking to represent modes of connection, and it can naturally reflect the two important connection modes in a neural network: dispersed connections (i.e., where a neuron puts out a nerve fiber to connect with several other neurons) and concentrated connections (where a neuron receives transmissions from several nerve fibers). This provides SLONN programs with excellent continuity.

B. There are three means for describing large networks in SLONN: repeated connections, modules, and module arrays, which enable SLONN to have a high capacity for network description.

SLONN is a high-level program design language that is an effective descriptive tool for large and small neural networks.

As an application example, we have used SLONN to describe parts of neural systems of the ocean snail and the Aplysia. Results of computer simulation experiments have shown that the networks so described are capable of producing excellent simulation for such behavior as the phototropism and conditioned chemical learning of the sea snail, and the habituation and sensitized chemical learning of the Aplysia. Relevant simulation experiments and neuron simulations in the SLONN language will be presented in another paper.

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Special Report on Shanghai Information Industry

Overview of Information Technology

40080064a Beijing JISUANJI SHIJIE [CHINA COMPUTERWORLD] in Chinese No 40, 19 Oct 88 p 42

[Article by the Main Office of the Shanghai Municipal Leading Group for Promotion of Electronics (LGPE): "Electronic Information Technology Leads the Way in Transforming and Promoting Shanghai Industries"]

[Text] Growth of the new international technological revolution in the 1980's has effectively promoted transformation of industrial structures and the role of technical progress is becoming increasingly evident in development of the national economy. Electronic information technologies are the most dynamic nucleus of the new technological revolution and they permeate over 90 percent of technical advances in traditional industries. Utilization and development of electronic information technologies concerns the overall situation and they occupy an extremely important strategic position.

Electronic information technologies refer to electronic hardware and software technologies used to collect, transmit, process, and store information. They include microelectronic technologies, computer technologies, software technologies, modern communications technologies, and interrelated technologies.

Shanghai, China's old industrial base area, has grown to occupy a more important status in China over the past few decades. Shanghai's socio-economic development is in an important transition period now and it faces serious international and domestic challenges. While China was making a gradual transition from an agricultural country with a predominantly rural population based on manual labor to an industrial country with a mostly non-agricultural population, Shanghai completed the shift to mechanization in the 1960's. Shanghai's economy is now in a period of changing from relying mainly on material resources to relying mainly on scientific and technical progress (that is, information resources). The structure of Shanghai's labor force can be expected to follow the international trend of continued growth in the population working in the information industry. Shanghai now has an opportunity to apply electronic information technologies

fully to meet the challenges of the new technological revolution and accelerate development of an export-oriented economy in Shanghai. If we develop smoothly, projections are that Shanghai could leap into the information era by the year 2000.

The Shanghai Municipal CPC Committee and Municipal Government approved establishment of the Shanghai Municipal LGPE in 1984 and made it responsible for promoting widespread utilization and development of electronic information technologies in Shanghai.

After setting up the Shanghai Municipal LGPE, it proposed the plan goal of continually perfecting utilization of electronic information technologies in Shanghai. Before 1990, development and application of electronic information technologies in Shanghai will mostly involve medium and small scale projects which require small investments, produce results quickly, and cover the broadest area. Microcomputers will be used widely with a focus on expanded utilization and design of application-specific and semi-application-specific integrated circuits, and there will be a major effort to develop software and make breakthroughs in key technical problems in Chinese language information processing, networks, and other areas. Shanghai will: 1) Establish 15 urban information systems; 2) Establish 100 computer-aided enterprise management systems and several integrated-production demonstration systems; 3) Establish 10 industrial computer-aided-design demonstration systems; 4) Select 10 breakthrough points for computer control and detection, and extend them through industry; 5) Develop 400 electromechanically integrated and microelectronic technology products.

In the past 4 years, on the basis of countermeasures taken by the Shanghai Municipal CPC Committee and Municipal Government to deal with the challenges posed by the new technological revolution, all battlefronts in Shanghai have adhered to the principle of "using information technologies as the main factor, making microcomputer applications the breakthrough point, and transforming the electromechanical, chemical, light industry, textile, handicraft, and other traditional industries to serve the promotion of Shanghai." They have gradually met the demands put forth by Vice Mayor Liu [0491] as representative of the Shanghai Municipal Government at the 1984 Shanghai Microcomputer Applications Work Conference. Greater acknowledgement of the importance of computer applications work has enabled organs at all levels of the Shanghai People's Government and many related departments to begin installing computers. They are also beginning to be used in vast numbers of industrial and communications enterprises and in agriculture. It began with computers installed in Shanghai's scientific research units, universities, middle schools, and extracurricular activity sites. They are beginning to enter every type of social service facility and information system in Shanghai at all levels. According to incomplete statistics, the number of computers in all of Shanghai grew from 1,640 in 1983 to 19,860 in 1987, a more than 12-fold increase. In 1984, the Political Work Report at the Second Session of the Shanghai Municipal People's Congress issued a call for the fifth of six campaigns. It called for first of all opening up microcomputer applications, focusing on computer-aided design and

computer-aided-management pilot projects, production process control, development of intelligent products, and moving from software development and personnel training to actual use and gaining experience in maintenance and upkeep. These tasks were victoriously completed after 4 years of effort.

As computer use has grown, progress in the original Shanghai Municipality Electronic Computer Applications Plan (1984 to 1990) has been excellent and it may be completed in excess of quotas.

Information Systems, Networks

40080064b Beijing JISUANJI SHIJIE [CHINA COMPUTERWORLD] in Chinese No 40, 19 Oct 88 pp 44-52

[Article: "Gradually Establish Urban Information Systems and Data Communications Networks in Shanghai With the Goal of Improving the Information Environment and Quality for Socioeconomic Development in Shanghai"]

[Excerpts] Shanghai is China's largest city. If one can say that a city is a spatial regional system having a concentrated population, concentrated economy, and concentrated S&T with the goal of deriving economic benefits, then Shanghai's 6,000 km^2 of land has concentrated a population of 12 million people, it has concentrated 145 industrial categories, and it has concentrated 421,600 talented S&T personnel who are busily engaged in economic, S&T, trade, financial, information, and cultural activities. They are responsible for one-sixth of China's export trade, one-eighth of total state revenues, and one-sixth of total commodity exports.

Deriving economic benefits depends on effective utilization of three types of resources: energy resources, materials, and information. Information is a resource much like energy and materials, and the degree of its importance and its status are being recognized with growing frequency. Electronic information systems, with computers and communications technologies as pillars, have now become the most important way to develop, produce, store, and utilize information resources. Urban information systems use electronic information technologies as tools and electronic information systems as concrete structures to collect, organize, process, transmit, and utilize all information resources in a city on the widest possible scale to integrate development of the city as a whole with electronic information technologies and improve urban quality. Comrade Zhao Ziyang pointed out in October 1983 that information systems are China's weakest link and that good information systems would certainly enable China to achieve its four modernizations drive ahead of schedule.

The Computer Applications Work Conference held in Shanghai in 1984 proposed a plan to build 15 information systems with the goal of improving the information environment and quality of socioeconomic development in Shanghai. Gratifying progress has been made in building Shanghai's urban information system. System development, construction, extension, and application have given us a more profound understanding of urban information systems, and we have perfected and expanded the Shanghai Urban Information System Program (SUISP).

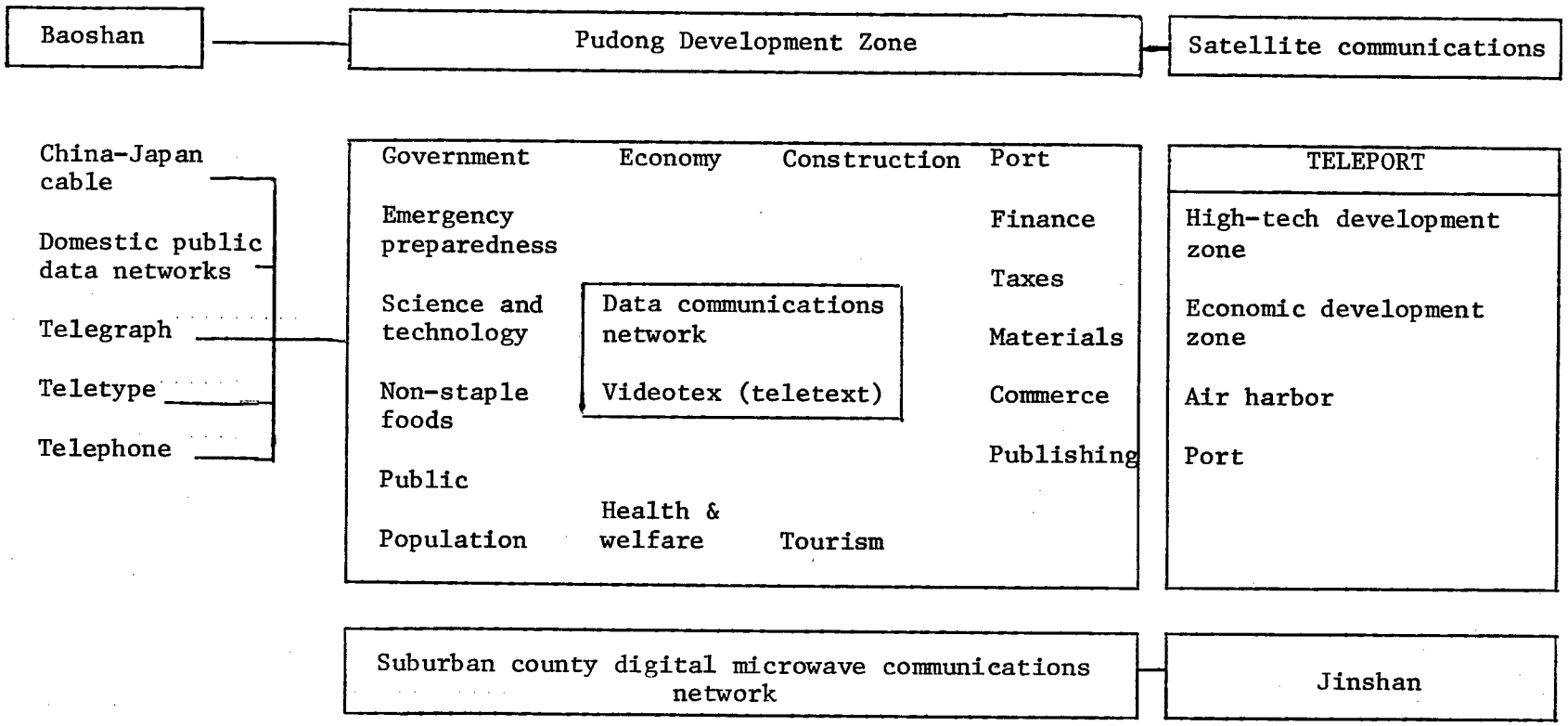
Baoshan
Pudong Development Zone
Satellite communications
China-Japan cable
Domestic public data networks
Telegraph
Teletype
Telephone
Government
Economy
Construction
Port
Emergency preparedness
Finance
Taxes
Science and technology
Data communications network
Materials
Non-staple foods
Videotex (teletext)
Commerce
Publishing
Public
Health & welfare
Population
Tourism
TELEPORT
High-tech development zone
Economic development zone
Air harbor
Port
Suburban county digital microwave communications network
Jinshan

Figure 1.

[Passage omitted]

IV. S&T Information Retrieval Systems

Shanghai Municipality is a region with rather concentrated S&T forces in China, and full utilization of its S&T advantages is the key to promoting the city. The Shanghai Municipal S&T Commission decided to set up several scheduled utility S&T information computer retrieval networks in the Shanghai region within 8 to 10 years. On the basis of existing work, the focus in the Seventh 5-Year Plan has been database construction and cooperation with posts and telecommunications departments to provide communications conditions in order to foster initiative in information, library, higher education, and scientific research units, accelerate system construction, and achieve sharing of Chinese and foreign information resources. The plan is first to focus on setting up eight databases of practical significance oriented toward terminal subscribers and open to society, and to further perfect subscriber public command sets and increase the degree of transparency for subscribers in using each database. The main computers in the network include four types: IBM 4381, DPS-8, Siemens 7536, and Burroughs B6954. The IBM PC/XT is the basic computer type for subscribers. The database units provide remote terminal simulation, and subscribers are given communications software on floppy disks. After connecting their microcomputer with the main database computers via the urban telephone network or dailing up via the long-distance network, subscribers can use the command key CSCS to retrieve file data from the database.

Currently, several different types of computers are being used in the Shanghai region and incomplete statistics show more than 14 types of medium and small scale information retrieval computer systems. To deal with problems involved in using different types of computers and different retrieval software, the Shanghai Regional S&T Information Computer Retrieval Network provides subscribers with retrieval public command sets for all types of computers to allow interfacing with system networks and database management systems. Shanghai now has a substantial number of IBM PC/XTs. This led the system to issue a full-function front-end software package for the IBM PC/XT and to use the IBM PC/XT as a long-distance intelligent terminal. This solved subscriber interfacing problems in the on-line information retrieval system.

V. Promoting Research and Experiments on Basic Facilities for New Transmission Media in Shanghai

Communications facilities in Shanghai have incurred rather large debts both in technical levels and equipment levels, and they lag far behind the world's other big cities. Centralized information is a primary characteristic of modern cities, and levels in information collection, processing, transfer, and so on serve as standards to determine whether a city is advanced or backward. Shanghai now faces pressure from a very low telephone coverage rate and challenges from the new technological revolution in transmission media. Projections are that the information volume will increase 238 percent by the year 2000, but the information volume in conversation, film, and other

spatial media will increase just 10 percent. The information volume in periodicals, books, and other material circulation-type media will increase by 65 percent. The information volume in telephones, telegrams, television, and other basic telecommunications media will increase 180 percent. The information volume in data communications, facsimile, cable TV (CATV), and other basic telecommunications media will increase 1,141 percent. Major changes will occur in the proportion of the total information volume accounted for by each type of transmission medium in the structure of the information volume. The information volume transmitted by spatial and material circulation-type media as a proportion of the total structure of the information volume will decline, whereas the information volume in new transmission media will rise to 22 percent by 2000. Developments in computer applications over the past few years have promoted the first steps in data communications and research on new transmission media in the Shanghai region.

At present, we find these three situations in data communications:

1. Dedicated line networks. Some subscribers with independent lines used their existing lines to develop data communications services like railway systems, electric power systems, metallurgical systems, long-distance transport systems, and so on.

2. Leased line networks. There are now seven subscriber data-transmission systems operating as networks which connect 21 large and medium sized computers. Two pairs of long-distance transmission lines were leased, and there are 173 leased dedicated lines within the city. The transmission speed is 1200 to 9600 bits/second.

3. Public data exchange networks. The Ministry of Posts and Telecommunications has arranged for Shanghai to import and install a national public data exchange nodal computer to create a national public data exchange network formed by Beijing, Shanghai, and Guangzhou. To promote the development of data communications in Shanghai, the Shanghai Municipal S&T Commission decided to establish a public data exchange experimental network for the Shanghai region during the Seventh 5-Year Plan. The experimental network is composed of three subgroup exchange node computers (NODE), three concentrators (PAD), and a network control center (NMC). The subgroup exchange node computers are located in central, west, and north Shanghai. The communications protocol in the public data-exchange network uses the X.25 international standard. The Shanghai Regional S&T Information Computer Retrieval Network was invited to join the network as the first subscriber of the experimental network. Each type of computer passes through a front-end processor (FEP) which converts the various network communications protocols being used into OSI [open systems interconnection] within ISO [International Standards Organization] to complete one part of the transport layer, session layer, presentation layer, and application layer, that is, the first part of the fourth, fifth, sixth, and seventh layers in OSI. Hard work by the relevant development units has produced key breakthroughs in developing subgroup exchange node computers and network control centers.

In addition, the relevant scientific research units are taking interest in Videotex [also called Teletext] as a visual information technology for use in urban information transmission. The Shanghai No 4 Radio Plant has cooperated with other units in successfully developing experimental prototypes for Videotex broadcasting.

VI. "TELEPORT" - Shanghai's Future

Shanghai is located on the central East China Sea coast, borders on the mouth of the Chang Jiang, and faces the vast Pacific Ocean. It is one of the world's biggest ports. To deal with their future in the 21st Century, all of the world's main port cities and big economic and trading cities have studied and deployed new development strategies, and all major cities have a strategic goal of fighting for information resources and a status as a world information center in order to maintain and secure their status as world economic and trading centers. Government authorities in New York City chose to deal with the current situation of 20 years of industrial decline in its harbor region by studying ideal situations for ports in the 21st Centry, and in 1982 New York's New Jersey Port proposed the ideal of "changing from material transfer ports to information exchange ports," or the TELEPORT concept. It quickly affected the world's main port cities and economic and trading cities and led to the appearance of a new "TELEPORT" industry. TELEPORT has become a new model for building information systems in the world's port cities. Now, New York, San Francisco, London, Paris, Amsterdam, Tokyo, Yokohama, Osaka, and other main port cities have proposed their own TELEPORT plans.

Pushed by the New York Long-Distance TELEPORT Plan, every nation in the world has extensively discussed the idea of long-distance TELEPORTs. Because conditions vary in each country, the concept of long-distance TELEPORTs is still in the development process and has gone through three main stages of development to date.

1. Stage one. Efforts were made to build terrestrial communications bureaus and to use them as a nucleus along with solid regional information network communications centers and so on to attract renters. New York's New Jersey Long-Distance TELEPORT is located in one of a large group of skyscrapers and they are searching for a new area to build an information stronghold with extremely limited electronic wave interference. With the rapid growth in the information volume in communications, it provides real-time processing of satellite and microwave communications between the central service area in New York City and all other cities.

2. Stage two. There was a focus on fixed property development, reinforcement of relevant facilities for communication with the mother city and its surroundings, efforts to create an environment most adapted to providing services, and using this to seek distinctions from traditional management offices and create an office park with even higher added value. This was determined by the organization of development andutilization of long-distance communication ports themselves. This is particularly true when fixed

property companies, construction companies, and other civilian enterprises participate and become the leading factors, which can give color to the development of fixed property.

3. Stage three. Create even more attractive functions, and plan a type of long-distance TELEPORT composite body.

To enable cooperation among countries with different communications conditions and language systems, common standards must be formulated to the greatest possible extent. Starting with this viewpoint, the World Long-Distance TELEPORT Joint Utilization Commission Conference was held in Los Angeles in 1984. The required limited definitions for long-distance TELEPORTs were made. Based on these definitions, long-distance TELEPORTs should have these three functions.

1. Provide communications network services to neighboring regions.

2. Provide communications access facilities for satellites and other forms.

3. Provide fixed property development functions.

The functions of TELEPORTs are shown in the accompanying illustration.

Shanghai is China's biggest and one of the world's biggest port cities. The State Council called on Shanghai to look outward to the world and toward the 21st Century to build it into a socialist modernized city with a prosperous economy, advanced S&T, developed culture, rational deployments, convenient communications, flexible information, and clean environment. "TELEPORT" is a new model for a highly effective information system that can be used to form more linkages between Shanghai and other areas of China and other nations, and to make Shanghai an international city with a strong radiative capacity, attractive capacity, and solid support capacity. The relevant experts have begun to take interest in the latent meaning of the "TELEPORT" concept for promoting the development of Shanghai and are providing favorable conditions and preliminary ideas for research on a long-distance TELEPORT in Shanghai.

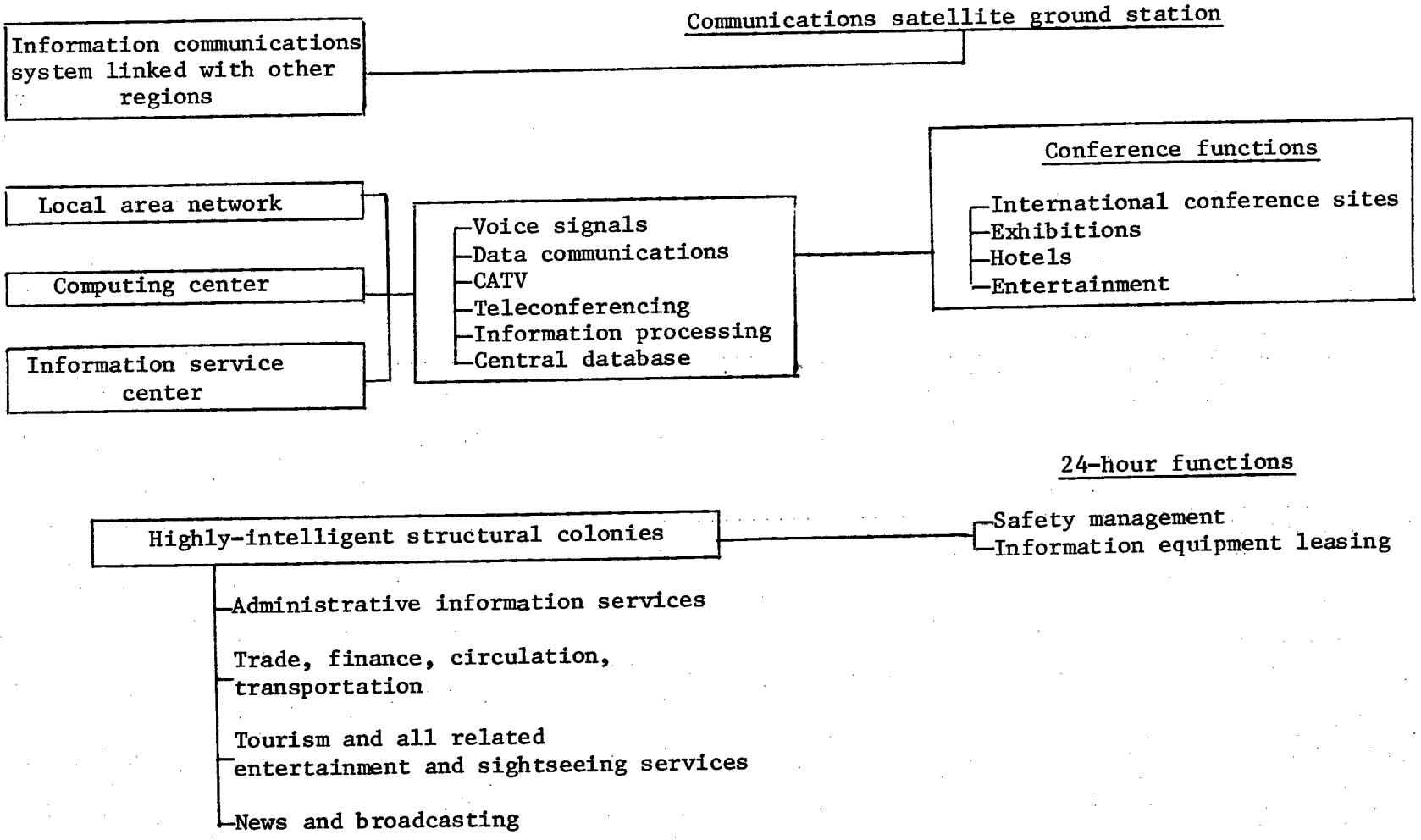
Communications satellite ground station
Information communications system linked with other regions
Conference functions
International conference sites
Exhibitions
Hotels
Entertainment
Local area network
Computing center
Information service center
Voice signals
Data communications
CATV
Teleconferencing
Information processing
Central database
24-hour functions
Safety management
Information equipment leasing
Highly-intelligent structural colonies
Administrative information services
Trade, finance, circulation, transportation
Tourism and all related entertainment and sightseeing services
News and broadcasting

Figure 2.

Item	Preliminary conditions for the development of a TELEPORT in Shanghai
Region	Hongqiao Development Zone, Minxing Development Zone, Caohejing New-Technology Development Zone, Hongqiao Air Harbor, Guangang and Xinzhuang satellite ground stations
Ground stations	Three, one completed (one Pacific Ocean satellite, one Indian Ocean satellite, one domestic satellite)
Capital construction	- Expansion at Guangang - Second-stage transformation of Hongqiao Air Harbor - Hongqiao High-Level Office Zone - Minxing Industrial Development Zone - Caohejing New-Technology Development Zone - High-speed highway networks and trunk highways linked to the city center - Culture, sports, and entertainment facilities
Networks	- In-port fiber-optic networks - Digital communications trunklines linked to the city center - Digital microwave communications trunklines linked to suburban areas
Characteristics	- Technical industry function - electronic technologies, biotechnologies, new materials technologies, etc. (technical information centers, personnel training organs, R&D colonies, development advisory financial risk investment systems, enterprise development systems, high-tech market centers, enterprise colonies, software engineering centers, CAD centers) - Materials circulation functions - convenient sea, land, and air comprehensive materials and personnel circulation systems - Information communication functions - integrated digital networks and information systems (TELEPORT information control and service centers, communications satellites) - High-level management functions - consular zones, intelligent office buildings, conference centers, world trade centers, hotels
Developers	- Government organs - Importing foreign capital - Leasing land utilization rights

Figure 3.

Applications to Traditional Industries

40080064c Beijing JISUANJI SHIJIE [CHINA COMPUTERWORLD] in Chinese No 40, 19 Oct 88 pp 54-62

[Article: "Use Information Technologies To Speed Up Transformation of Traditional Industries and Accelerate Development of the Export-Oriented Economy"]

[Excerpts] The 13th Congress of the CPC Central Committee pointed out that economic construction in China is responsible for the dual tasks of promoting revolution in traditional industries and leading the way in catching up with new technical developments in the world. New technologies, represented by electronic information technologies, play an especially important role in promoting technical progress in traditional industries, improving scientific management levels, and increasing exploitation of production potential. Based on the strategic goals and plans formulated by the State Council LGPE and the Shanghai LGPE which focus, respectively, on industrial colonies and product colonies, microcomputer applications are being used as breakthrough points in selecting mostly medium and small scale projects that produce results quickly to accelerate the transformation of traditional industries in Shanghai and speed up development of the export-oriented economy.

I. Focus on 10 Breakthrough Points

The production equipment in some industrial enterprises in Shanghai is rather outdated and employs poor technologies. Some old equipment has outlived its term of service and is operating at an overload, which has intensified contradictions among processing capacity, processing levels and the development of production technologies. This situation makes market competition difficult. We must use microcomputer technologies to transform production equipment to achieve technical progress and substantially increase production capacity in enterprises. The Shanghai Municipal Economic Commission has called on all industrial bureaus and enterprises to take action in applying microcomputer technologies to transform mechanical equipment according to specific characteristics with a focus on breakthroughs in these 10 areas:

1) Adopt digital display and numerical control (NC) technologies to transform machine-tool equipment. Key industries for extension: electro-mechanical, shipbuilding, agricultural machinery, textiles, etc.; Goal: transform 4 to 5 percent of the metal cutting equipment in Shanghai, about 7,000 units. 2) Use microcomputer automatic control (MAC) equipment to transform industrial boilers larger than 10 tons and all types of ovens and kilns. Key industries for extension: metallurgical, chemical industry, textiles, light industry, pharmaceuticlas, etc.; Goal: 500 sites. 3) Apply MAC in rubber sulfurization equipment (tanks) and dense smelting furnaces. Key industries for extension: chemical industries, light industry, etc.; Goal: 800 units, more than 85 percent of the total in Shanghai. 4) Apply microcomputer wired and radio control technologies to

achieve power-load control. Key industries for extension: enterprises and transformer stations which consume rather large amounts of power; Goal: control all units. 5) Use microcomputers to control dyeing vats and shuttle looms. Key industries for extension: textiles; Goal: 500 high-temperature high-pressure yarn-dyeing vats and 1,000 shuttle looms. 6) Use microcomputers or programmable controllers to control electroplating production lines. Key industries for extension: light industry, electromechanical, agricultural machinery, etc.; Goal: 30 electroplating lines. 7) Use "model distinctions," "multivariate statistics," "linear programming," "process modeling," and all other adjustment and optimization techniques to optimize production processes. Key industries for extension: petrochemical, chemical, pharmaceutical, etc.; Goal: 15 key enterprises. 8) Use microcomputers to control fermentation and production processes. Key industries for extension: light industry, pharmaceutical, chemical, etc.; Goal: 5 sets. 9) Apply microcomputers to control the chemical fertilizer synthesis process. Key industries for extension: chemical, agricultural machinery, etc.; Goal: one or two model enterprises. 10) Apply microcomputers to control materials mixing in vertical cement kilns, aqueous ball preprocessing, and closed kilns. Key industries for extension: agricultural machinery, etc.; Goal: one or two model enterprises.

In the past few years, on the basis of demands made at the National Conference on Technical Transformation of Mechanical Equipment With Microelectronics, Shanghai's industrial system has focused on applications plans, applications development, and applications trials in using microelectronic technologies to transform several pieces of machine-tool equipment and make progress in the 10 breakthrough points.

Digital display technologies and economical NC equipment have been actively extended throughout Shanghai to transform existing machine-tool equipment. By the end of June 1987, Shanghai had transformed a total of 928 pieces of machine-tool equipment, including 547 units which use digital display technologies with 974 [total] coordinates, and 361 units which use economical NC equipment systems. It has now shifted from transforming mainly lathes to transforming milling, grinding, planing, electric-spark processing, and other types of special-purpose machine-tool equipment, with rather good economic results. The Shanghai No 7 Textile Machinery Plant invested 3 million yuan to apply NC technologies to transform 42 machine tools and to use digital displays with 77 coordinates in 39 metal-cutting machine tools. This substantially changed the backward situations in production equipment, processing techniques, inspection and testing measures, and other things throughout the plant, which accelerated product development and promoted the development of production. In the past, this plant developed one new product in 5 years, but it now develops two or three new products every year. Moreover, product quality, performance, technical levels, and input/output rates have improved compared to the past and efficiency has risen every year. The Shanghai Micro-Bearing Plant invested 120,000 yuan over a 2-year period in 1985 and1986 to apply microcomputer technologies to transform 34 automatic machine tools of seven varieties. The breakdown rate for equipment electrical control dropped from 1.5 percent to 0.2 percent, which increased team and group production by an average

of 3.6 percent. This could increase output by 680,000 yuan in 1 year, with rather evident input/output results. Moreover, quite good economic and technical benefits have been gained from using microelectronic technologies to transform machine-tool equipment at the Pengpu Machine Plant, Gas Turbine Plant, Shanghai Lightbulb Plant, and several other units.

Several achievements have been made in applying microelectronic technologies in industrial furnaces and kilns. Various types of heating furnaces, kilns, and drying chambers at 103 sites have been transformed in the metallurgical, chemical, pharmaceutical, instrument electronics, and other industries. The pace of transformation has been particularly rapid for furnaces and kilns in the metallurgical system, with obvious energy savings. They formulated a furnace and kiln transformation plan and an implementation plan which were integrated with major overhauls, technical transformation, and extension and application of microcomputer technologies. Over the past 2 years they completed transformation tasks at 53 steel rolling furnaces, annealing furnaces, equal-heating furnaces, and industrial boilers. Using microcomputers in heating furnaces alone can reduce metal burning loss and reduce energy consumption by 5 to 10 percent. These two items can create benefits of 2.13 million yuan each year. Preliminary achievements have been made in applying microcomputer technologies in industrial boilers, glass tank furnaces, and heating furnaces of various specifications used in the instrument and electronics industries, which has laid a definite foundation for further extension.

In the area of applying microcomputers for automatic production control in rubber sulfurization equipment and dyeing vat equipment used in the textile industry, transformation tasks had been completed for more than 300 sulfurizers (and tanks) and 250 textile-dyeing vats, which has improved product quality and production efficiency. Microcomputer control of 80 sulfurizers at Shanghai's Zhongnan Rubber Plant can increase bicycle-tire output by 235,000 pieces in 1 year and produce an additional 1.85 million yuan in output value and 850,000 yuan in profits taxes, while conserving 117 tons of coal.

Besides focusing on these 10 breakthrough points, there are many aspects to using microelectronic technologies to transform traditional industries in Shanghai. The Shanghai Umbrella No 2 Subplant is using microcomputer-controlled lasers to cut cloth for umbrellas and has now put together a workshop which can save 55,000 square meters of nylon cloth and 220,000 yuan in funds each year. This has led to gradual growth from manual labor to automation, something not reported elsewhere in the industry internationally.

II. Focus on Construction of CAD System Demonstration Points for 10 Industries

Shanghai Municipality's application plan goals are to set up CAD/CAM demonstration systems in 10 industries during 1990, to raise design efficiency by 2 to 15 times, and to organize 30 percent of design personnel in this industry to study CAD technologies.

After several years of efforts, the goals in this goal have gradually been realized:

Shipbuilding industry	China Shipping Corporation Applied Software Development Center
Integrated circuit industry	Shanghai Integrated Circuit Design Center
Construction industry	East China Structural Design Academy
Electronics industry	CHP-Kaige Applied Demonstration Center
Machine industry	Shanghai Metallurgical and Mining Machinery Plant
Molding industry	Shanghai Jiaotong University Molding Institute
Space industry	Shanghai CAD/CAM Center
Clothing industry	Shanghai No 1 Clothing Plant
Printing and dyeing industry	Shanghai No 10 Printing and Dyeing Plant
Petrochemical industry	Shanghai Petrochemical Complex Design Academy

To date, investments and personnel in Shanghai's CAD system account for about one-fourth the national totals. A preliminary scale has been attained at the 10 industrial demonstration systems and some have entered the stage of actual utilization. They are providing advanced technologies for product design in the industries and they have trained a large group of engineering and technical personnel who understand CAD technologies. This has shortened design schedules, improved product quality, accelerated substitution of higher-grade products, increased market competitiveness, and provided rather good benefits.

Shanghai's shipbuilding industry was one of the first industries to adopt CAD/CAM, and it has moved from the demonstration stage to the extension stage. The Jiangnan Shipbuilding Plant, Hudong [East Shanghai] Shipbuilding Plant, and several other industrial enterprises have undertaken CAD work. The China Shipping Corporation's Software Development Center has established 12 large-scale integrated systems for ship construction price quotes, preliminary design, manufacture, electromechanical equipment design, and so on which have formed a preliminary complete set of shipbuilding CAD/CAM software. Using CAD/CAM in shipbuilding can increase overall results by about 30 percent, and the value from savings of steel plate alone for a 36,000-ton vessel can be as high as 160,000 yuan. The shipbuilding management system program systems and shipbuilding management and operation statistical analysis software developed by the relevant units earned U.S.$55,000 and $100,000 in foreign exchange.

The Shanghai Integrated Circuit Design Center organized relevant units in the Shanghai region to undertake attacks on key problems in the Seventh 5-Year Plan and all are now engaged in their work according to plan. A two-stage integrated circuit design system has entered the utilization stage. This system has already input 300 man/years and completed a 500,000-statement CAD software development task. It provides applied CAD tools for design input, graphics editing, design verification, simulation analysis, semi-automatic and automatic domain design, and testing that can be used for all stages of MOS [metal oxide semiconductor] and bipolar-type ECL [emitter-coupled logic] technology chip design, which increased efficiency by several 10-fold.

The microcomputer die-punching and cutting CAD/CAM system successfully developed by the Shanghai Jiaotong University Molding Institute can be used for drop-feed dies, piercing drop-feed dies, and piercing drop-feed common continuous dies $\leq$ 3 mm thick and up to 600 mm X 600 mm in size with a press tonnage of no more than 100 tons, and it has great extension and utilization value.

The Shanghai No 10 Printing and Dyeing Plant hasa computer-aided printing and dyeing pattern preparation system which eliminates traditional manual pattern scanning. It prints the original pattern distinctly on the fabric with fresh colors and strong three-dimensional imagery. Production of one wholesale batch of a single type of bedsheet can provide net profits of 300,000 yuan and foreign businessmen are competing to buy them.

Since going into operation, the computer-aided clothing pattern design, trimming, rejection, and automatic cutting systems at the Shanghai No 1 Clothing Plant have been used successfully for size trimming, rejection, sketching, and cutting high-grade men's and women's fashions. The computerized automatic trimming speed is 3 times higher than when done manually and with a 3 percent reduction in materials quotas during trimming.

[Passage omitted]

IV. Trial Integrated Production Systems

Technical levels in Chinese enterprises are backward compared to advanced enterprises internationally, and management levels are even lower. Scientific management in advanced enterprises in the developed nations has gone through three main stages. The Taylor system initiated the era of scientific enterprise management. Around 1945, scientific enterprise management developed into its second stage, which focused on mathematical modeling along with advanced computing tools. The third stage began in the 1980's with integration of CAD/CAM (computer-aided design and computer-aided manufacturing), PPC (production process control), ROBOT, MRPII (manufacturing resource planning), DSS (decision-making support system), ASRS (automated storage and retrieval systems), and so on.

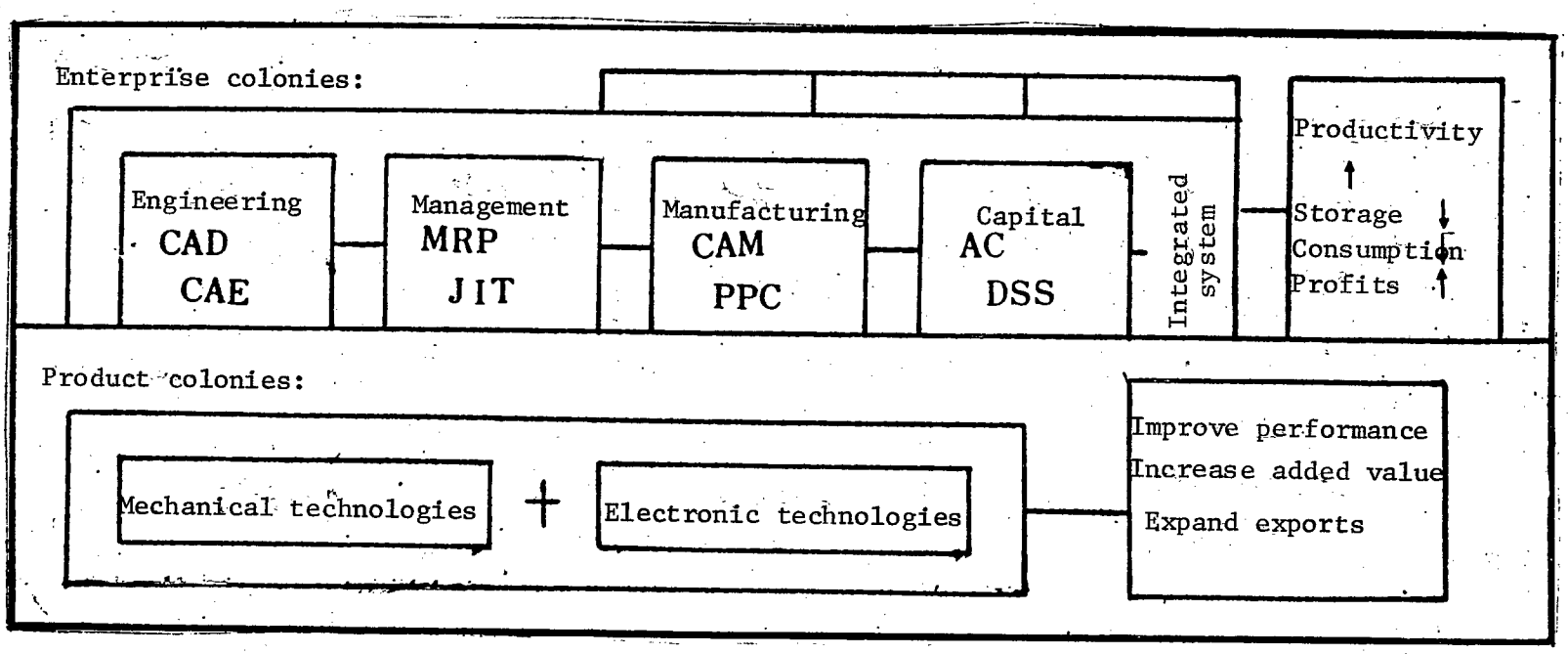
Enterprise colonies:
Engineering
CAD
CAE
Management
MRP
JIT
Manufacturing
CAM
PPC
Capital
AC
DSS
Integrated system
Productivity
Storage
Consumption
Profits
Product colonies:
Mechanical technologies
+
Electronic technologies
Improve performance
Increase added value
Expand exports

Figure 4.

Enterprise management levels in China still are rather low, but there is extreme instability and unreliability, particularly in the environment outside the enterprise. This means that some intractable problems may be encountered in implementation of more advanced modern production management techniques which will hinder comprehensive extension. Shanghai, however, is China's most important industrial base area and management levels have a definite foundation. To increase the international competitiveness of Shanghai's large and medium-sized backbone enterprises and accelerate the city's shift toward an export-oriented economy, the Shanghai Municipal LGPE decided to study and try establishing computer-integrated manufacturing systems (CIMS) in a few enterprises with the proper conditions.

After carefully analyzing advanced aspects of modern management in foreign countries and China's national conditions, the Shanghai Metallurgical and Mining Machinery Plant formulated comprehensive principles for CIMS systems: 1) CIMS technologies have been a developmental direction of world industrial circles for the past 20 years and the key to enterprise existence and growth for the past 10 years. This was the goal in establishing CIMS at the Shanghai Metallurgical and Mining Machinery Plant. 2) Do not pursue excessive automation and take full account of actual conditions in China. 3) Adopt and develop matrix-type interface boundaries between factory functional departments and computer software to deal with current system reforms. 4) Consider enterprise capacity to bear economic burdens and establish hardware systems composed mainly of minicomputers and microcomputers. 5) Use systems engineering as a guide to divide the achievement of principles into stages.

Their hardware system contains three main parts: a SABRE 5000 CAD/CAM system, HP3000 MRP system, and PC-level interfaces. The software system contains two main parts: a technical system and management system. The technical system is mainly responsible for machine parts and components, product design, and graphic storage and retrieval. The management system is mainly responsible for the plant's central database, tracking and controlling materials flows, planning production materials, managing production costs, finances, resources, and so on. To achieve integration, PC-level hardware technologies were used with group technology (GT) and bill of materials (BOM) software as bonding agents between the technical system (CAD/CAM) and management system (MRP).

From the CIMS perspective, systems are divided into the four main links of design, technology, manufacturing, and management and into 10 main subsystems.

1. Computer-aided design. Establish component databases/standard component databases with group encoding systems. Establish algorithm databases for conventional components (like axles, keys, chains, etc.). Establish algorithm databases for primary products (decelerators, electric dust removers, etc.). Do finite element analysis of key components used in primary products. Searches and plotter output diagrams. Compile product design files. Design jigs and hand tools.

2. Computer-aided technical design. Establish statistical software required for group technologies. Establish interchangeable code system software. Establish component-technique classification software. Establish databases for hand tools, special knives, and tools. Variable-type computer-aided technical software. Work-time quota measurement and management.

3. Computer-aided manufacturing. Computer-aided plate material selection and sampling. Computer-aided box-shaped and pipe-shaped component expansion. On-line NC flame-cutting machines. CNC [computer numerically controlled] processing centers. On-line multi-spindle boring and milling machines. Transform old equipment to achieve direct numerical control (DNC).

4. Computer-aided testing and quality control. Establish workshop on-site position variable work-procedure testing systems. On-line three-coordinate measurement systems. Collect quality information on key component processing and assembly procedures, with statistical and tabular output. Manage in conjunction with quality assurances for system tracking of the useful life of components, parts, and products.

5. Manufacturing resource-planning systems. Establish component and materials inventories and product-mix databases. Establish materials-storage databases. Establish production-resource databases. Manage the provision of each processing item of component-processing procedures. On-line materials receiving and shipping. Management to confirm the tracking of each item in user's contracts. Management to track purchased items. Manage work order tracking. Arrange for progress toward production plans. Arrange for materials requirements plans. Arrange for production capacity requirement plans. Workshop processing information and production statistics. Management for tracking planned component costs and actual costs.

6. Sales contract management. Establish user information management databases. Establish sales contract benchmarks. Comprehensive tracking management of contracts. Comprehensive management of product storage, shipping, and invoicing. Analysis of sales and user conditions, statistics, and graphic output. Product forecast analysis. Price quotes for all primary products.

7. Computer-aided equipment management. Establish archival databases for all plant equipment. Arrange equipment repair/maintenance plans. Projection analysis for components needed by equipment. Graphic output of equipment maintenance and upkeep data and statistics. Establish component storage databases. Manage on-line receiving and shipping of all components. Manage tracking of component purchases. Manage work-order tracking for maintenance shop processing and production statistics.

8. Computer financial management. Establish full-plant financial income and expenditure management systems. Manage product cost budgets. Full-plant capital balance and analytical and graphic output. Statistical and tabular output of all types of finances.

9. Computer-aided personnel archives database. Employee and cadre personnel archives databases. Analysis and projection of labor power requirements. Production labor statistics. Comprehensive statistical examination and management of all types of personnel information. Wage accounting and bonus distribution.

10. Computer-aided energy resource monitoring. Collect and monitor data on consumption of water, power, gasoline, coal, oil, and other energy resources. Energy-resource data statistics and analysis.

After the projects were implemented, the design time to produce identical components dropped about 40 percent, the degree of standardization rose 7 percent, production time was reduced 8 percent, new jigs were reduced by 7 percent, non-productive schedules were reduced 28 percent, engineering design costs were 15 to 30 percent lower, and new product-development schedules shrunk 30 to 60 percent. The circulation efficiency of remanufactured goods rose 30 to 60 percent. Worker production efficiency increased 40 to 70 percent. For an electric dust-remover used in a 600,000 kW power plant, for example, the model-selection and price-quoting schedule was reduced by a factor of more than 10 and the weight of each unit was reduced by more than 20 percent. Cost savings exceeded 1 million yuan. Product-design schedules were reduced by an average of one-third and product competitiveness internationally was enhanced. Added to the benefits from comprehensive management, the yearly benefits were in the range of 2.5 to 3 million yuan, so the investment can be recovered in 2 years.

V. Injecting Microelectronic Technologies Into Products

An enterprise is the basic economic cell of society and products are the lifeline of industrial and commercial enterprises. Injecting microelectronic technologies into products gives them a new technical foundation. This is the primary direction of product updating and replacement in the modern era, and it is the key technology for improving product competitiveness. This is particularly true of integrated computer, electronic, and information technologies, which has created a new generation of "electromechanically-integrated" high-tech product groups. The Shanghai Municipal Instrument and Telecommunications Bureau and Machine-Building and Electronics Industry Management Bureau formulated an intelligent product plan and electro-mechanically-integrated product plan, and they have worked for years to develop many new products with concentrated technologies, high efficiency, and low energy consumption which have replaced original traditional products and gradually improved product mixes and technical contents. They also have trained several key technical cadres who have enhanced their ability to develop applied microelectronic technologies.

Shanghai Municipality's electromechanically-integrated products have developed especially well in these realms: NC machine tools, intelligent instruments and meters, electronic measuring tools and devices, industrial robots, electronic household appliances, electronic medical instruments, electronic drive-speed control devices, electronic low-voltage electric

components, microcomputer controlled instruments and packaging machines, microcomputer controlled printing and dyeing machines, electronically controlled vehicles and internal combustion engines, and electronic automated power-plant control equipment.

The Shanghai No 4 Machine-Tool Plant has developed a third-generation machining center, the XH 764 Horizontal Machining Center, which uses a vertical-movement configuration to shorten the drive chain and assure rigidity in the feed system drive. The main axle has a highly rigid structure matched with a constant intake temperature lubricating system to assure the high-precision requirements of the main axle system. Every guide surface crushes the hard clumps of plastic, and operational characteristics are excellent. The product also has an interchangeable work station which can greatly improve product efficiency and enable expansion to an FMC [flexible machining cell]. The main drive system has a DC electric motor directly driving the rotation of a toothed synchronizing belt to increase main drive stability and vibration resistance and substantially reduce machine tool noise. PC components used in the heavy current system improved operational reliability, reduce external dimensions, and achieve electromechanical integration. An interchangeable selectable pattern is used for the chain type cutting tools to facilitate operation.

The CNC-7500 NC [oxyacetylene] gas cutter developed by the Shanghai Gas Welding Machine Plant uses advanced FANUC-DESK7CM system control and employs high-speed microcomputers and various electronic storage devices to meet every need for processing speed and absolute minimum use of steel plate. It has the advantages of saving time and improving work quality. The 7CM system can use rotating applications devices for feedback to achieve closed-cycle control, but the biggest benefit is that it integrates design equipment and processing during execution. This machine uses a double-sided drive pattern in the vertical direction which has electronic equipment to assure strict synchronization of the two electric motors, and it uses steel belt followup in the horizontal direction to allow equidirectional and mirror image cutting.

The QKZ series microcomputer program-controlled paper-cutting machine is a new type of paper-cutting machine designed and developed by the Shanghai Paper Cutting Machine Plant in cooperation with the Shanghai Electrical Automation Institute. This product line is composed of the main equipment, drive, paper pressing, paper transfer, hydraulic, high current, and microcomputer controlled components.

This series of products has intelligent functions and various digital and control keys on the control faceplate to store technical procedures for cutting. Programs can be revised, inserted, or removed, and stored procedural data is maintained in the event of a power outage. It also includes metric and English system conversion, error alarms, equidistant cutting, instructional programming, and other auxiliary functions. Moreover, it is capable of manual, semi-automatic, or automatic operation, so it is safe and reliable, easy to program, consumes little energy, and increases efficiency by 50 to 70 percent.

The CLZ100 three-coordinate measurement machine is a development and production task assigned by the Ministry of Machine-Building & Electronics Industry to the Shanghai Machine Tool Plant which was developed in cooperation with Hefei Industrial University. A three-coordinate measurement device is a large high-precision measurement instrument developed within the past 20-plus years in foreign countries. It can be precisely positioned in three-dimensional space to measure many complex dimensions. The CLZ100 three-coordinate measurement device uses a conventional computer and can make basic measurements in three-dimensional space. It can measure errors of flatness, roundness, sphericity, cylindricality, and other shapes, and it can search for measurements on a flat curve. It is written in several independent modules and is extremely easy to transfer.

The Shanghai Municipal Electromechanical Industry Management Bureau has successfully developed 103 electromechanically-integrated products over the past few years, and the bureau's plan is to complete 150 electromechanically-integrated products in 20 major categories throughout the bureau by 1990 and produce them in wholesale quantities. The focus, which is centered on microelectronic technologies, is on developing programmable controllers, NC systems, digital display for component inspection, drive systems, and associated components in combination with using them selectively in power plant transmission and transforming equipment, vehicles, machine tools, light industrial machinery, industrial boilers, and the variable-speed energy-saving "three engines and one pump."

Each year, the Shanghai Municipal Instrument and Telecommunications Industry Bureau has compiled a separate "intelligent product" plan which calls on all units under its jurisdiction to develop new categories and accelerate product updating and replacement. The plan for 1988 arranges for 144 intelligent products including 32 optical instruments, 74 instruments and meters, 29 types of electronic instruments and equipment, 6 broadcast televisions, and 3 semiconductor components.

To achieve the goal of controlling electric power at the household level proposed by the State Council LGPE, a power load controller (model MPK-3) developed by the Shanghai No 2 Power-Meter Plant has been converted from sending an analog signal input into a watt-hour pulse input which has added measurement, control, printing, and recording functions for reactive power, COSϕ and voltage value. The Shanghai No 4 Automatic Meter Plant and Shanghai No 34 Radio Plant developed a wireless power-load regulation and control system that carries out load regulation and control at a distant implementation terminal from the central control console.

To deal with the large amount of capital now being spent to import instruments and meters for technical transformation, the Shanghai Municipal Instrument Bureau organized projects which "use products for peak progress":

Microcomputer controlled graphite oven	United States PE Company Model HPA-3
Infrared carbon and sulfur analyzer	United States LECO Company Model C.S
Computer controlled near-contact optical engraver	Japan Canon Company PALA-501
AC standard current voltage source	Japan product 2558
0.2 grade digital three-phase power meter	Japan product 2533
Portable infrared radiation thermometer	Japan Senno[?], England Kane-May Company
Intelligent standard pressure signal generator	United States AMETEK Company
Self-rectifying PID temperature regulator	United States WEST 2071
Digital microhmmeter	Switzerland (Titankesi)
EPROM programmer/eraser	Japan MINATO 1863
Superhigh-frequency microvolt meter	England 9303
Intelligent logic oscilliscope	England TA2163
100-Megohm wide oscilloscope	Philips 3263
Solid state sweep-frequency meter	United States HP8635

The main role of electronic information technologies in developing electromechanically-integrated products has been in the areas of automated inspection and testing, automatic regulation and control, data collection and processing, digital display and printing, and automatic breakdown diagnosis. The primary form through which microelectronic components have permeated the product mix is at the system level, the board level, the chip level, and the special-purpose integrated circuit level.

Shanghai's ability or inability to put together the capacity to design and develop application-specific integrated circuits (ASIC's) is particularly important, and it is the key to Shanghai products being able to squeeze into international markets. ASIC's have advantages like being small in size, difficult to copy, a good price/performance ratio, high reliability, and so on. The Shanghai Municipal Integrated Circuit Design Center was

established to make fullest use of the favorable factors for developing ASIC's in Shanghai and actively do good ASIC extension and applications work. Participating units include Fudan University, Shanghai Jiaotong University, Shanghai Semiconductor Components Institute, Shanghai No 5 Components Plant, Chinese Academy of Sciences' Shanghai Metallurgy Institute, Shanghai No 14 Radio Plant, Shanghai Chang Jiang Integrated Circuit Design and Applications Company, Institute 615, and others. The design center is responsible for attacks on key technical problems in computer-aided design of integrated circuits, developing and integrating computer-aided design software, and establishing an applied design system to reinforce ASIC design, development, extension, and utilization in the Shanghai region.

To date, they have developed:

Application-specific circuits	Application
Washing-machine control circuit	Semi-automatic dual-tub washing machine
Special-purpose telegraph circuit	TDM/22/46 telegraph transmitter
Special-purpose circuit for use in communications equipment	DS2 [8 Mbps] multiplexing/drop-insert system buffer memory
Special-purpose circuit used in sewing machines	Computerized sewing machine
Special-purpose speech processing circuit	Speech processor
Time-series control circuit	Time-series allocation controller

Several types of application-specific circuits for use in data conversion channels, pulse distributors, and so on also are being developed. In conjunction with the development of application-specific circuits, the Shanghai Municipal Integrated Circuit Design Center has completed 100-plus gate-array element databases which have laid a preliminary foundation for improving design efficiency of application-specific and semi-application-specific circuits.

Development of Laser-Guided Cart for FMS

40080139 Beijing JIXIE GONGYE ZIDONGHUA [MACHINE-BUILDING INDUSTRY AUTOMATION] in Chinese No 1, Jan-Mar 89 pp 5-8

[Article by Chen Yongguang [7115 3057 0342], Laboratory of the Hefei Institute of Electronic Engineering, and Ren Yongyi [0117 3057 4135], Teaching and Research Section No 805, the National Defense University of Science and Technology: "Research on a Laser-Guided Unmanned Transport Vehicle for FMS"]

[Text] (Abstract) This paper describes a laser-guided unmanned cart for use in an FMS [flexible manufacturing system]. A Z80 microprocessor allows this vehicle to achieve a high degree of flexibility. The chassis uses a pair of drive-wheels, and the difference in speed between the two wheels is used to guide the small vehicle. The engine revolution speed is determined by the width of the driver pulse; a pulse-width modulator constructed in hardware can generate a driving pulse with a higher precision of width than can one using software methods. In doing so, one can use a high-frequency driver pulse to improve the dynamic characteristics of the D.C. servomotor, and this driving mode improves rotational precision.

Preface

FMS's need unmanned material-flow systems, and the unmanned cart is just the [right] new transport device for use in an FMS.[1] The key to unmanned-vehicle technology lies in the guidance mode; the unmanned vehicles currently used in an FMS are either electromagnetically or photoelectrically guided; the former is easier to use, but it is difficult to alter the route it travels; the latter is not reliable, as its metal guide track is easily contaminated. For these reasons, it is imperative to develop a new mode of guidance. Since the end of 1986, we have been studying laser-guided unmanned carts having a maximum speed of 0.5 meters per second and an error in steady-state guidance of $\pm$5 cm (that is, the greatest gap between the point of the received laser beam and the center line of the cart). Furthermore, we are going to be studying carts that can be programmed and that have functions allowing correction by left or right turns.

Although laser-guided unmanned carts have yet to be applied as frequently as the electromagnetic types, researchers are attracted by their excellent precision and flexibility. It can be predicted that laser-guided unmanned carts will be used in FMS's in the near future.

The Principles of System Structure

The principles of system structure are as shown in Figure 1. The left and right wheels of the left-engine-driven and right-engine-driven cart operate symmetrically. They form a relatively independent rotational closed loop with each H-type bipolar power amplifier, pulse-width modulator, digital regulator, and photoelectric coded disk. The digital regulator is implemented in computer software, the pulse width modulator consists of computer hardware, and the photoelectric coded disk is used to give feedback on rotation-speed load. The H-type bipolar power amplifier is a proportional component, the motors (left and right) are second-order components, and the electromechanical time constant and the magnetic constant were obtained empirically. The output of the left and right motors is rotation speed, the left and right wheel positions are obtained through an integral component, and the difference between the positions of the two wheels and external perturbation determine the amount of deviation for the cart in relation to the laser. This shift amount controls this paired-input, paired-output system in accordance with the opposite polarity and the input terminals for the left and right speed rings. Because the two left and right closed speed loops themselves are relatively independent, each speed ring can be designed according to a single variable system, by which one can avoid the complex calculations of multiple-variable controllers while using the simpler digital regulator to accomplish the control function. And because the digital regulator is simple in form, data processing speed is fast, which then satisfies the demand for real-time control of the unmanned cart. Both digital simulation and actual operation have proven that the unmanned cart we have designed can travel stably along a laser beam and that it also has good noise immunity, which then proves the correctness of this design concept.

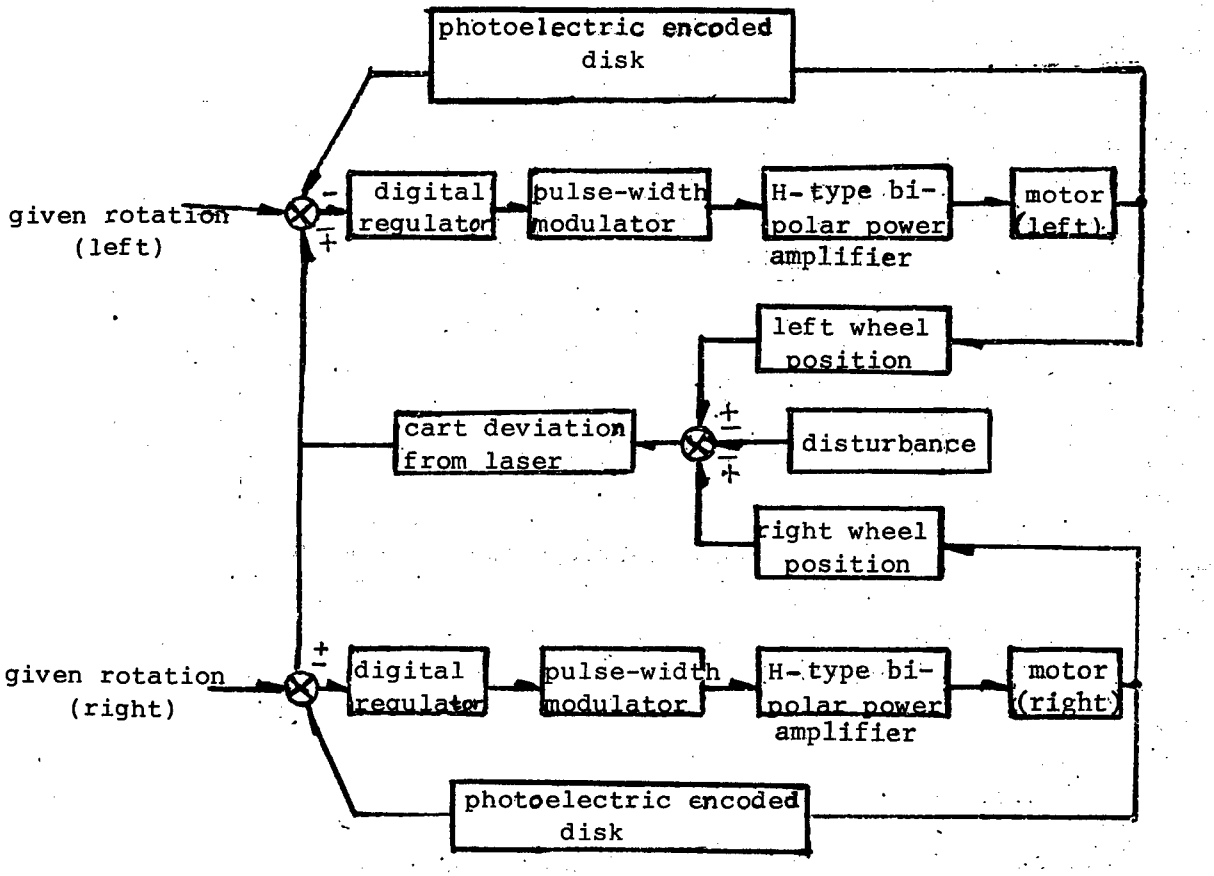

Figure 1

Implementation of the Control System

Figure 2 is an overall view of the control system configuration; the unmanned-cart numerically controlled (NC) system is centered on a Z80 microcomputer, where the system sampling period is 10.24 ms [milliseconds].

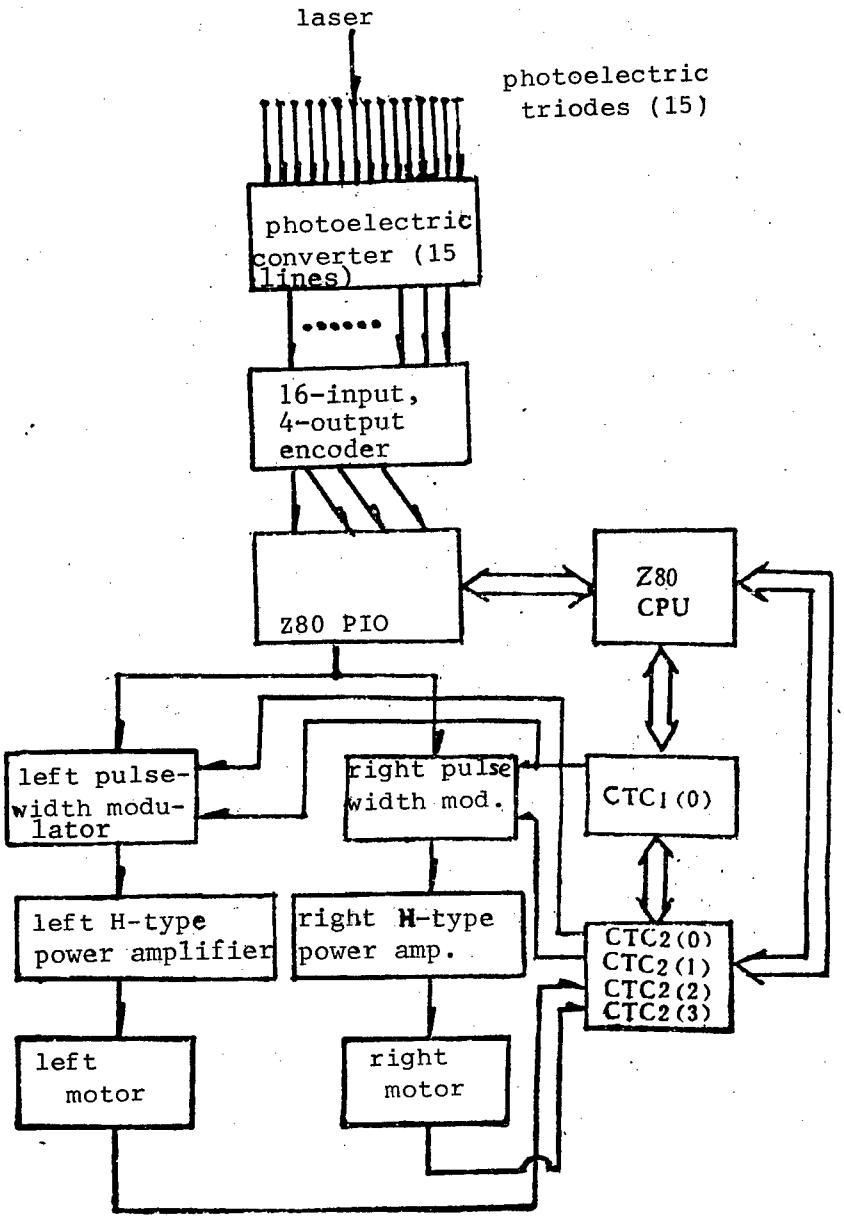

Figure 2

A row of 15 photoelectric triode receiver guidance lasers are placed over the top of the unmanned vehicle, and after the laser signals are converted into electrical signals, they are sent to a 16-to-4 encoder. Each photocell corresponds to a code, which is sent to port A of the Z80 PIO [parallel input-output]. During each sampling period, the computer will read the value at port A. If the code read is that from the central photocell, the computer will know that the cart is traveling exactly along the laser path. If the code is that from either a left or right photocell, it knows

that the cart is traveling in an erroneous direction and that it must change the speed differential between the two wheels. The deviation of the cart direction will be corrected during each sampling period, by which means the unmanned cart can be completely guided by the laser as it proceeds.

The left and right motors are pulse-driven, where those pulses are of a particular width generated by the pulse modulator according to values calculated by the Z80. The CTC2 channels 0 and 1 in Figure 2, together with some digital components, make up the pulse-width modulator. The CTC2 is an extension from the Z80. Channel 0 of CTC1 provides a clock signal (256 microsecond cycle) for the pulse width modulator at periodic intervals, and the driving pulse, at nearly 4 KHz, can greatly reduce oscillation of the motor current.

Normally, software is used to generate pulses of a particular width. However, if we want to reduce the oscillation of a small-motor current, we must raise the pulse frequency. Because of a higher frequency, the smaller differential in the pulse width will lead to a greater difference in average voltage for the motors, which will then bring on a serious drop in rotational precision. But the average time for executing a Z80 instruction is 5 microseconds, and if we were to use software to generate the pulses, there would be great discrepancies in control of the system. Even worse, off-and-on interrupts would delay the entire sampling cycle, while as random sampling cycles are added, the response of the control system will decrease. Because we have designed a hardware pulse modulator that generates pulses at widths determined by the Z80 CPU (the width value is sent from the CPU to channels 0 and 1 of CTC2), the problem just described is basically resolved.

The pulse output by the pulse modulator is converted by the H-type bipolar power amplifier into the motor voltage. The voltage polarity and size area are determined by the difference between the positive-negative pulse widths as generated by the pulse-width generator.[2] If T_1 (positive pulse width) is less than a half-cycle, the motor will turn in reverse. By making the left and right wheels turn in opposite directions, we can achieve our goal of keeping the unmanned cart from greater blind spots when turning around in a given location.

Two photoelectric isolation diodes are installed in the H-type bipolar power-amplifier circuit to effectively separate strong motor current from the computer TTL [transistor-transistor logic] levels. Under the protection of the photoelectric isolation diodes, the Z80 is relatively secure, as there is no danger of damage by strong current.

The Z80 CPU [central processing unit] is the key component in the digital control. Channel 1 of CTC1 is the counter for the ZC/TO [zero count/timeout] signal of Channel 0 (256-microsecond cycle), and when the counter value reaches 40, the CTC generates an interrupt-request signal each 10.24 milliseconds. During the period of execution for each interrupt-response routine, the Z80 computer will accomplish the following operations:

1. it will acquire the left/right motor speeds (Channels 2 and 3 of CTC2 count the left/right-motor rotation speed through the photoelectric coded disk);

2. it will calculate the deviation of the cart from the laser;

3. it will calculate the digital regulator value;

4. and it will place the new pulse width on Channels 0 and 1 of CTC2.

When the load of the cart changes, the control parameters may be conveniently changed.

Figure 3 shows the Z80 10.24-millisecond-cycle interrupt processing procedure. Sometimes, when the cart is bumped or strongly jolted, it might be shifted out of range of the laser guidance, so to keep the cart on track, the received laser codes must be checked; if a zero, the computer will know that the cart has not yet received the laser beam, and it will again read-in the code that was read during the last sampling cycle. In this way, even though for a short time the photoelectric triode will not have seen the laser, no guidance errors will occur that cannot be compensated.

During the next sampling cycle, the Z80 can simultaneously output the adjustment values for the left and right motors.

Experimental Results

Experiments have included the two categories--the digital simulation and actual operation. The simulation was done with the system structure that is shown in Figure 1. Figure 4(a) reflects how the system controls external disturbance, and we can see that the laser guidance allows the effects of the disturbance to be quickly reduced to zero, and Figure 4(a) shows how the system has the capability of eliminating disturbances. Figure 4(b) shows the situation where the rotation speeds of two motors are changing. Laser guidance will allow the unmanned cart to change position, and when the degree of change in position has met the goal that would eliminate the effects of disturbance and allow the cart to resume its proper direction, the difference between the speeds of the two motors will once again be zero, as the rotation speeds of the two motors operate in unison.

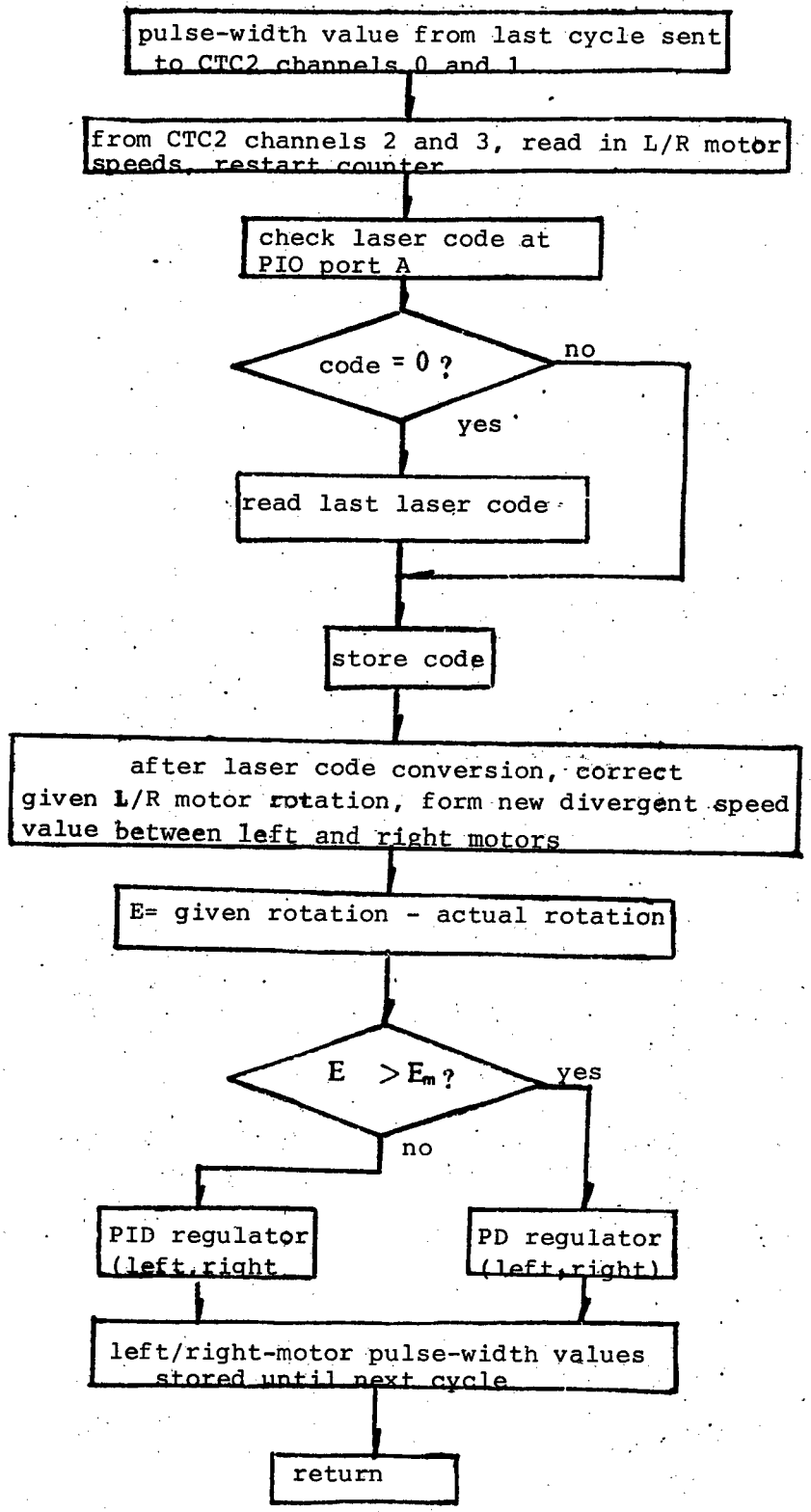
pulse-width value from last cycle sent to CTC2 channels 0 and 1
from CTC2 channels 2 and 3, read in L/R motor speeds, restart counter
check laser code at PIO port A
code = 0 ?
no
yes
read last laser code
store code
after laser code conversion, correct given L/R motor rotation, form new divergent speed value between left and right motors
E= given rotation - actual rotation
E > Em ?
yes
no
PID regulator (left,right
PD regulator (left,right)
left/right-motor pulse-width values stored until next cycle
return

Figure 3

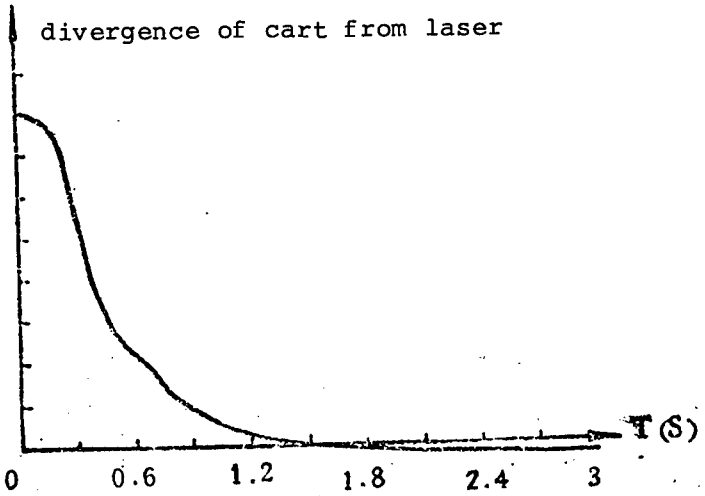

Figure 4 (a)

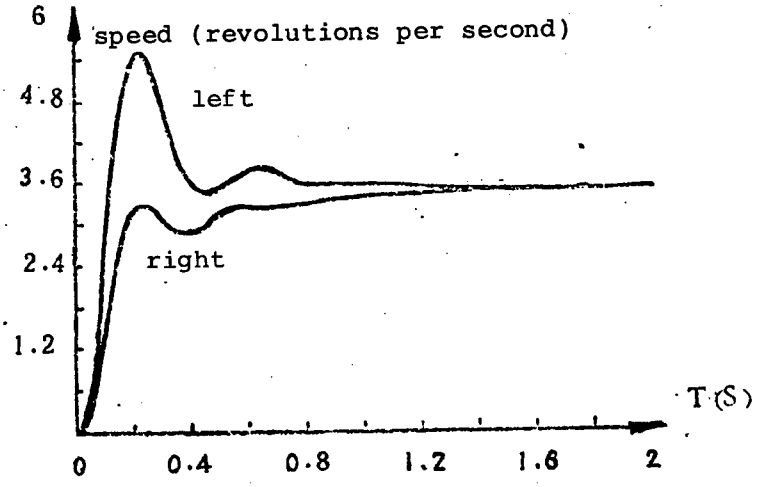

Figure 4(b)

The results of actual operations are shown in Tables 1 and 2.

Table 1. Range of Divergence

(initial angle of Ø)

speed (in meters per second)	stable divergence (in cm)
Ø.1	-1 ~ +1
Ø.12	-1 ~ +2
Ø.14	-2 ~ +2
Ø.18	-2.5 ~ +2.5
Ø.2	-2.5 ~ +3
Ø.23	-3 ~ +3
Ø.25	-4 ~ +4
Ø.5	-4.5 ~ +5

Table 2. Capacity for Controlling Disturvance

(cart traveling speed: 0.2 meters per second)

initial angle (degrees)	dynamic divergence (cm)	correction time (secs)
-15	±1Ø	3Ø
-1Ø	± 3	2Ø
- 5	± 5	1Ø
Ø	± 2.5 ~ +3	Ø
+ 5	± 9	15
+1Ø	±15	23
+15	±2Ø	35

Table 1 shows the range of divergence under different speeds (where the initial angle of divergence is Ø). The higher the speed, the greater the divergence, and the greatest discrepancy is 5 cm. Table 2 reflects the capacity of the system for immunity from disturbance. At the time of initiation, the cart is at a particular angle to the laser. After a few seconds of disturbance, the unmanned cart is traveling along the laser track. The greater the angle, the longer the time of correction and the broader the range of disturbance. If the angle is not too great, the unmanned cart can travel stably.

Conclusions

The unmanned cart can play an important role in FMS. Laser guidance is one advanced means for guiding the cart, and it is therefore quite important for the new types of FMS.

The manned cart we have developed has been proven to be a system that is highly stable, flexible, and precise in guidance, and as its advantages have been shown in several experiments, we hope that it can be of use in the new types of FMS.

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Large-Aperture CW Injected TEA CO_2 Laser With Stable Cavity

40080114a Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 16 No 1, 20 Jan 89 pp 7-10

[Article by Ye Donglai [0673 2639 0171], Li Dianjun [2621 3013 6511], and Lin Taiji [2651 1132 1015] of the Changchun Institute of Optics and Fine Mechanics, Chinese Academy of Sciences: "Large-Aperture CW Injected TEA CO_2 Laser With a Stable Cavity"; manuscript received 25 Sep 87]

[Text] Abstract: This paper describes a tunable large-aperture CW [continuous-wave] injected TEA CO_2 [transverse-excitation atmospheric CO_2] laser. The performance characteristics of the laser are analyzed and experimentally investigated. The feasibility of single-frequency output is also qualitatively analyzed.

I. Introduction

Many TEA CO_2 laser applications, such as laser radar and laser isotope separation, require single-frequency output of the TEA CO_2 laser. There are several ways to achieve single-frequency output of the TEA CO_2 laser.[1] In a non-injected single-frequency stable-cavity TEA CO_2 laser, a suitable diaphragm is placed in the cavity to prevent the formation of higher-order transverse modes. The technique to control (or select) the gain of neighboring longitudinal modes is used to achieve a single longitudinal mode (single frequency) output.[1] Although the diaphragm limited higher-order transverse modes, it also blocks the use of the energy stored in the activated medium in that region which drastically reduces the energy output of the laser.[2] Such a system is often very complex and costly. In order to enhance the energy output, TEA CO_2 lasers with unstable cavities have been used to conduct injection experiments to obtain high-energy, high-peak-power single-frequency laser output.[3-5] Since the unstable cavity can automatically choose its basic mode, it no longer needs a diaphragm to limit higher-order transverse modes. Almost the entire activation media is the mode volume. However, the spatial light intensity distribution is no longer Gaussian. In addition, most researchers have used a normal stable cavity structure which results in a ring-shaped output. This is not desirable in certain applications.

This paper consists of a theoretical analysis and experimental studies on the performance characteristics of a large-aperture CW injected stable-cavity

TEA CO_2 laser and qualitatively explores the feasibility of using such a laser for single-frequency output.

II. Experimental Setup

The experimental setup is shown in Figure 1. The TEA CO_2 laser cavity is of the UV pre-ionization type. The cathode is a net and the anode is a Zhukovsky (?)-type electrode. The activation gas volume is 4 x 7 x 50 cm^3 and the ratio of gases is CO_2:N_2:He = 1:1:4; pressure is 600 Torr. Both ends of the activation region are sealed with NaCl Brewster windows. The aperture is 17.0 mm (also used as the diaphragm). The excitation power supply is a two-stage Marx generator with a 0.1-μF capacitor for energy storage. The operating voltage is 48 kV. M_6 is a 10-m-radius gold-plated concave mirror. G_2 is a Littrow first-order reflection, zero-order diffraction grating (100 lines/mm). The first-order reflectance is 50 percent (at 10.6 μm wavelength). The mirror and the grating are placed on two invar rods. The length of the cavity is 170 cm, corresponding to 88 MHz. Light is injected into the cavity through a ZnSe plate which is placed at approximately 40° with respect to the optical axis.

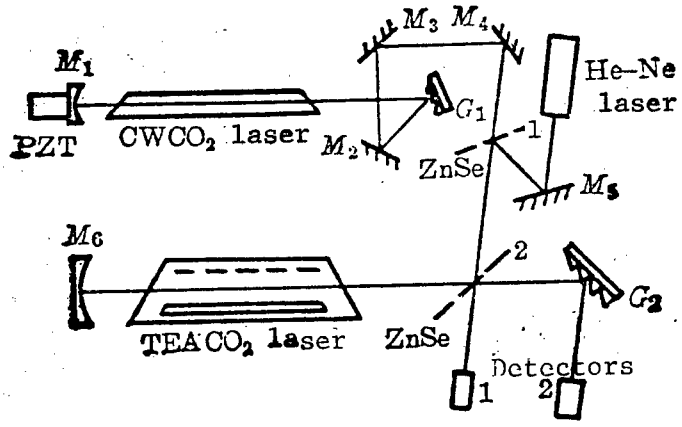

Figure 1. CW Injected TEA CO_2 laser

The injector is an external-cavity grating tunable CW CO_2 laser. The ratio of gases is CO_2:N_2:He = 1:1:8 and the pressure is 11 Torr; discharge current is 10 mA. M_1 is a 2.85-m-radius gold-plated concave mirror. The first-order reflectance of the shining grating G_1 (100 lines/mm) is 85 percent. The grating G_1 and mirror M_2 are installed on a rotating device. The intersect of their normal planes coincides with the axis of rotation. Moreover, it is parallel to the lines of the grating. This type of structure has a permanent polarization effect. When the grating is rotated to change the output spectral line, the direction of the light remains unchanged. The cavity is 100 cm long and all elements are secured on two steel rods. The laser output power ranges from 0-2.0 W. M_2, M_3, M_4 and M_5 are totally reflecting flat mirrors. The He-Ne laser is used to adjust the optics.

Detector 1 is used to monitor the magnitude of the light injected. The output of the TEA CO_2 laser is measured by a model LPE-10 energy meter. The wave form of the pulse is captured by a photon drag detector and a storage oscilloscope. A CO_2 spectral analyzer is used to tune the injector and the TEA CO_2 laser to the same spectral line.

III. Experimental Results and Discussion

Figure 2 [not reproduced] shows the output wave form of the large-aperture CW injected stable-cavity TEA CO_2 laser. Part (a) shows the typical output wave form when there is no injected light or when the injected light is not effective (the mismatch between the injected light frequency and the closest TEA cavity resonance frequency is high). The laser puts out light in multiple frequencies. Part (b) shows the wave form with effective injected light (frequency mismatch is small). The main peak is a smooth single-frequency output. It is followed by small pulses at various frequencies. This is mainly because the resonance transfer energy between N_2 and CO_2 is picked up by the noise field and then amplified.

When the injected light intensity is controlled at above 12.8 mW/cm^2 and the light fills the entire diaphragm (aperture 17.0 mm), the probability of getting an effective injection is 50 percent. This suggests that the aperture of an injected single-frequency stable-cavity TEA CO_2 laser can be much larger than that of a non-injected single-frequency stable-cavity TEA CO_2 laser (which is approximately 8 mm). This is because of the difference between an injected and a non-injected single-frequency stable-cavity TEA CO_2 laser. The initial signal intensity of every cavity mode near the center of the gain curve of a non-injected laser is almost identical. In addition, the frequency spacing between two neighboring transverse modes is much smaller than that between two neighboring longitudinal modes (see Equation (2)). It often needs a diaphragm to limit the formation of higher-order transverse modes and to control the gain of various longitudinal modes to realize a single longitudinal mode (frequency) output. As for an injected laser, because the injection intensity is much greater than the initial intensity of any other cavity mode (spontaneous-radiation field strength), the injected light can fill the entire diaphragm as long as the frequency is matched. Compared to other frequencies, the injected cavity field can rapidly reach saturation. This allows the laser to draw on the energy stored in the activation medium and produce a single-frequency output.

Since a spherical mirror stable cavity is a confocal cavity and the effective Fresnel number of the experimental TEA cavity $N_e \geq 1.6$, the spatial distribution of the TEM_{mn} mode can be approximately expressed as a Laguerre-Gaussian function:[6]

$$u_{mn}(r, \varphi) = C_{mn}\left(\sqrt{2}\frac{r}{w_{0s}}\right)^m L_n^m\left(2\frac{r^2}{w_{0s}}\right) \times e^{-\frac{r^2}{w_{0s}}} e^{-im\varphi} \qquad (1)$$

where (r,φ) is the polar coordinate on the mirror, C_{mn} is a normalization constant, w_{os} is the waste radius of the basic mode, and L_n^m is an expression for the associated Laguerre polynomial. The resonance frequency of the cavity is:

$$\begin{cases} \nu_{mnq}=\dfrac{C}{2\eta L}\left[q+\dfrac{1}{\pi}(m+2n+1)\right. \\ \qquad \left.\times \arccos\sqrt{g_1 g_2}\right] \\ g_1=1-L/R_1 \quad g_2=1-L/R_2 \end{cases} \tag{2}$$

Equation (2) shows that the cavity mode is highly (or approximately highly) degenerate with respect to frequency. If the injected frequency matches with a longitudinal frequency of the TEM_{oo} mode of the TEA cavity, because the injected light can be decomposed into various higher-order transverse modes of different longitudinal modes (different q) based on Equation (1), it also matches the frequencies of these higher-order transverse modes. This allows the laser to draw on the energy stored in the activated media to produce a single-frequency output in multiple longitudinal and transverse modes.

Since there is no spatial mode-matching, the matching coefficient between the injected light field and the TEM_{oo} mode of the TEA cavity is 0.2. The injected light would be more effective with spatial matching. With spatial matching, it is equivalent to an increase in the injected light intensity. Because effective injection can be achieved at 10^{-5} W/cm^2,[7] and light intensity can be varied at above 10 mW/cm^2, there is sufficient light intensity. Furthermore, the injected light spot may be very large without mode matching, which is beneficial for the large-aperture, high-energy, single-frequency pulse output of the TEA CO_2 laser.

The above experiment was carried out on the 10P(20) line. The output of the laser was 600 mJ. If an 8-mm-diameter diaphragm is put in the cavity to limit higher-order transverse modes, the energy output is only 80 mJ. Similar results were obtained when switching the operating spectral line from 10P(14) to 10P(32). In our laboratory, the pumping source for the para-hydrogen Raman pool is a single-longitudinal-mode TEA CO_2 laser oscillator with a multi-stage amplifier system.[2] The energy output of the oscillator is 200 mJ (operating voltage 60-70 kV). If the injected TEA CO_2 laser described in this paper is used as the oscillator, we can save 1-2 stages of amplification. However, because an injected large-aperture single-frequency stable-cavity TEA CO_2 laser has multiple transverse mode outputs, the divergence angle is much larger than that of a basic-mode TEA CO_2 laser. It is not directly suitable for long-range applications, such as laser radar.

In order to analyze the performance of the CW injected TEA CO_2 laser, we used an IBM-PC/XT computer to conduct a numerical computation based on the mathematical model proposed by Lachambre.[8] The parameters are as follows:

Reflectance of output mirror: R = 50 percent
Power transmittance in empty cavity: T = 80 percent
Cavity length: L = 170 cm

Activated medium length: $l = 50$ cm
Total pressure: $P = 600$ Torr
Gas ratio: $CO_2:N_2:He = 1:1:4$
Gain: $\alpha_{max} = 0.02$ cm^{-1}
Injected light intensity: $I_i = 0.01$ W/cm^2

The results are shown in Figure 3. Figure 3(a) shows that when the mismatch between the injected light frequency and the closest resonance frequency is significant (df = 36 MHz), the injected light has little effect and can be neglected. (The output power of the injected-light field strength is not shown; it is only $1/10^8$ of the spontaneous radiation field strength.) The laser has a multi-frequency output, as in free operation. The output wave form is shown in Figure 2(a). Figure 3(b) shows the number of inverted particles. When the frequency mismatch is small (df = 30 MHz), the injected-light field controls the laser output. The calculated results are shown in Figure 3(c) and the wave form is shown in Figure 2(b). The main pulse is a single-frequency output. The laser frequency is the cavity resonance frequency closest to the injected light frequency.[8] Figure 3(d) shows the number of inverted particles in this situation.

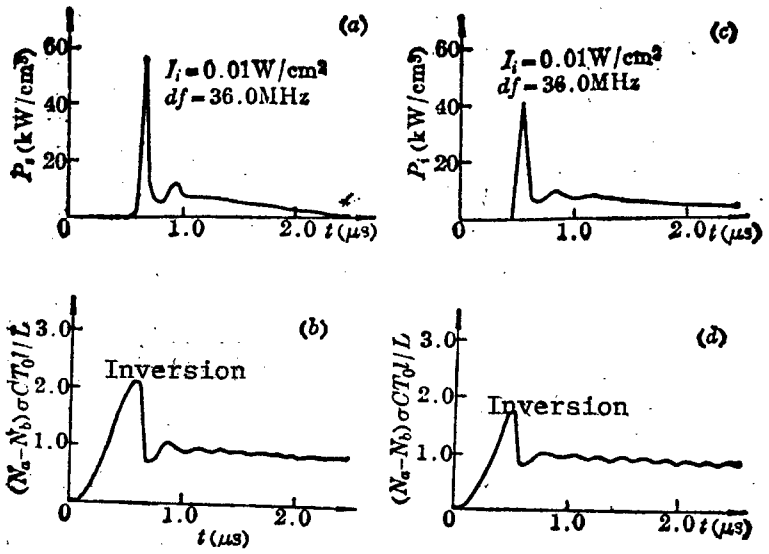

Figure 3. Theoretical Computation of Free Operation and Effective Injection

A comparison of Figures 3(a) and 3(c) and 3(b) and 3(d) shows that inverted particles are consumed earlier when injected light is effective. The laser pulse also appears earlier. Furthermore, the effect of the gain switch of the system is less significant. The peak power drops and tail rises and becomes longer. The output wave form pictures shown in Figure 4 [not reproduced] illustrate this point. The noisy signal is the spark gap trigger and the second peak is the main laser pulse. In free operation (a) the time delay between the main laser peak and the trigger is 0.8 μs and the peak voltage is 128 mV. When the injection is effective (I_i = 15.2 mW/cm^2) as shown in (b), the time delay is 0.58 μs and the peak voltage is 74 mV. The

photographs also show that the laser pulse has a higher and longer tail with effective injection compared to free operation.

When frequency mismatch is further reduced, the main pulse appears earlier. The pulse width increases, peak power drops and the tail rises and lengthens. The theoretical results are shown in Figure 5. Due to limitation in experimental conditions, we did not directly measure the effect of frequency mismatching. The following set of data clearly illustrates the dependence of laser pulse width, delay time and peak power upon frequency mismatch. It is in good agreement with calculated results.

Injected light intensity	Pulse width	Delay	Peak value
6.8 mW/cm^2	100 ns	0.75 μs	130 mV
6.3 mW/cm^2	90 ns	0.77 μs	140 mV

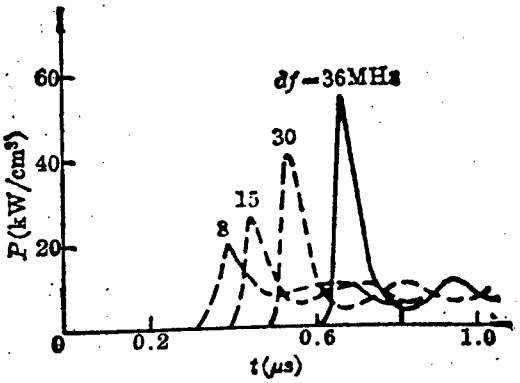

Figure 5. Theoretical Computation With Identical Injected Light Intensity at Different Initial Frequency Mismatches. The solid line in the figure represents free operation and the three dotted lines correspond to different frequency mismatches with effective injection.

The experimental conditions for Figure 4 are different from those for the above data. The laser was operating at 10P(20) and 10P(28), respectively. Only a portion of the output was used for observation and photography. However, the fraction is different.

We wish to thank Niu Zhenya [3662 2182 0068] for his assistance in the experimental work.

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Asymmetrical Pulse Oscillation in DH-GaAlAs Laser

40080114b Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 16 No 1, 20 Jan 89 pp 11-15

[Article by Zhan Yushu [6124 3768 2579], Xu Baoxi [6079 1405 6007], Xu Changcun [6079 7022 1317], and Guo Siji [6665 1570 0679] of Physics Department, Northwest Institute of Telecommunications Engineering [now renamed Xidian University], and Fang Fang [2455 5364] of the Beijing North China Computer Institute: "Study of Asymmetric Pulse Oscillation of DH-GaAlAs Laser"; manuscript received 3 Jul 87]

[Text] Abstract: This paper describes the experimental results from a study of the asymmetric pulse oscillation of the DH [double heterojunction]-GaAlAs semiconductor laser. Numerical results obtained by solving the rate equation of the laser are used to explain the observed asymmetric pulse oscillation effect. The asymmetric-pulse-oscillation operating region of the semiconductor laser--i.e., the range of dc bias current, radio-frequency current, and frequency modulation when asymmetric laser pulses are generated--is calculated.

I. Introduction

Paoli first observed the sub-harmonic pulse oscillation of the GaAlAs laser by bombarding a GaAlAs bar with protons[1] in 1981. He injected a 1.2-GHz microwave current into the laser diode and analyzed the frequency spectrum of the laser. It was found that the laser pulse has a repetition frequency of 600 MHz, exactly 1/2 of the driving current frequency. Kawaguchi and Otsuka also obtained a sub-harmonic pulse laser output[2] when they attempted sinusoidal microwave modulation with an InGaAsP-SAS laser diode in 1983; the modulation frequency was 3.1 GHz and the laser pulse repetition frequency was 1.55 GHz. The work done by Paoli and Kawaguchi is limited to the case where the dc bias current is larger than the threshold current. No further theoretical analysis was done.

When we used the DH-GaAlAs semiconductor laser prepared by the Semiconductor Institute of the Chinese Academy of Sciences and by the Shanghai Institute of Optics and Fine Mechanics to conduct ultra-short-pulse experiments, in addition to sub-harmonic pulse oscillation, we also found the more general asymmetric pulse oscillation. Our experimental observation suggests that sub-harmonic oscillation is a special case of asymmetric pulse oscillation.

The observed phenomenon can be explained by solving the rate equation of the semiconductor laser. Moreover, we can calculate the operating region of the asymmetric pulse oscillation. Numerical analysis indicates that under certain conditions the semiconductor laser may generate a sub-harmonic pulse oscillation at one-third of the frequency, i.e., one laser pulse with the injection of three current pulses. Detailed results of the numerical analysis are given in Section III of this paper.

As far as we know, no one has analyzed this asymmetric pulse oscillation in depth. Therefore, it is important in theory and practice to study this effect.

II. Experimental Results

The experimental set-up is shown in Figure 1. The dc bias current and radio-frequency modulation current are applied to the laser diode LD through the drive circuit. LD is a double-heterojunction GaAlAs semiconductor laser with a single transverse mode and multiple longitudinal modes. Its threshold current is 75 mA and the slope efficiency is approximately 0.3 mW/mA. The drive circuit also plays an impedance-matching role. Therefore, the radio-frequency power P_{RF} monitored by the microwave power meter is proportional to the square of the radio-frequency current I_{RF} impressed on the laser diode. The laser pulse was measured with a GT-231 avalanche photodiode (APD) and displayed on an SQ-27 sampling oscilloscope. The quantum efficiency of the GT-231 APD is 60 percent and the response time is 200 ps; bandwidth of the SQ-27 oscilloscope is 1 GHz. The response time of the entire system can meet the requirement of $f_m \leq 1$ GHz.

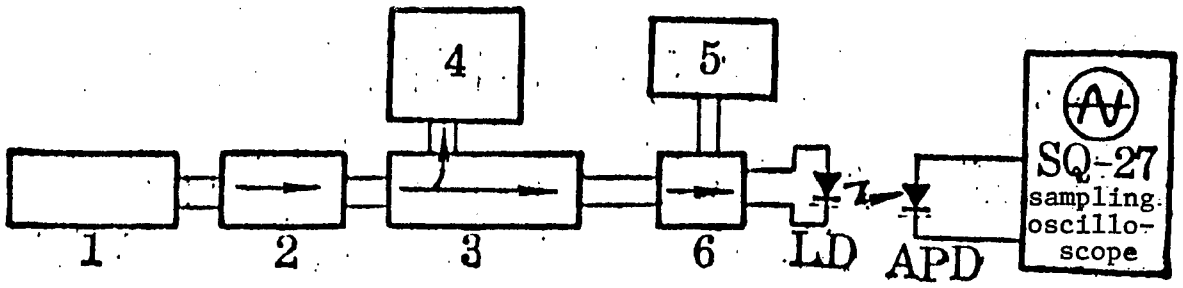

Figure 1. Block Diagram of the Experimental Set-up

1--150-1,000-MHz signal source; 2--variable attentuator; 3--directional coupler; 4--microwave power meter; 5--dc power supply; 6--drive circuit; LD--semiconductor laser; APD--avalanche photodiode

Figure 2 [not reproduced] shows the dependence of output laser pulse upon radio-frequency power when the modulation frequency is at f_m = 850 MHz. The threshold current of the laser used in the experiment is I_{th} = 75 mA. The dc bias current is I_{DC} = 60 mA, which is less than the threshold current. When the radio-frequency power P_{RF} is over 0.242 W, the output is a normal laser pulse (see Figure 2(a)). If the radio-frequency power is lowered, an

asymmetric laser output as shown in Figure 2(b) may appear. In this case, the series consists of alternating high and low pulses. This type of pulse series is known as asymmetric pulses in radio technology. Therefore, the laser pulse oscillation shown in Figure 2(b) is called asymmetric laser pulse oscillation.

As the radio frequency power decreases, the lower-intensity laser pulse becomes weaker and eventually disappears from the series, as shown in Figure 2(c). The repetition frequency of the pulses is 1/2 of that of the drive current. This is sub-harmonic laser pulse oscillation. Hence, sub-harmonic pulse oscillation is a special case of asymmetric pulse oscillation.

The presence of asymmetric pulse oscillation is closely related to the modulation frequency f_m. In our experiment, when the frequency of the radio-frequency current (i.e., modulation frequency f_m) is below 500 MHz, asymmetric pulse oscillation was never observed even though other parameters were varied. Figure 3 [not reproduced] shows that the laser pulse changed from symmetric to asymmetric and then to sub-harmonic oscillation when f_m is equal to 500 MHz. From Figure 3 we can see that the asymmetric oscillation is much weaker than that at f_m = 850 MHz.

When the radio-frequency power remains unchanged and the dc bias current is varied, it is possible to make a symmetric pulse oscillation into an asymmetric pulse oscillation and an asymmetric oscillation into a sub-harmonic pulse oscillation. Figure 4 [not reproduced] is an example. When f_m = 1 GHz and P_{RF} = 0.88 W, the asymmetric laser pulse oscillation shown in Figure 4(a) turns into the sub-harmonic pulse oscillation shown in Figure 4(b) by varying the dc bias current from 45 mA to 42 mA.

All experimental results indicate that asymmetric laser pulse oscillation can only be produced within a certain range of bias current, radio frequency and frequency. There is an area where the laser parameters (I_{DC}, I_{RF} and f_m) produce asymmetric pulse oscillation. Outside this area, the laser either produces normal symmetric pulse oscillation or nothing at all.

III. Theoretical Analysis

The rate equations for the semiconductor laser are

$$\frac{dN_e}{dt} = \frac{J}{ed} - A(N_e - N_0)\,N_p - \frac{N_e}{\tau_e} \tag{1}$$

$$\frac{dN_p}{dt} = A(N_e - N_0)\,N_p - \frac{N_p}{\tau_p} + B\,\frac{N_e}{\tau_e} \tag{2}$$

where N_e and N_p are the carrier concentration in the activated layer and photon density, respectively. N_p therefore represents the output light intensity. J is the injected electron density and d is the activated layer thickness. τ_e and τ_p are the carrier and photon life, respectively. N_o is the carrier density during particle distribution inversion. A is a gain dependent constant. B is the percent of spontaneously emitting light

incident upon the laser mode. Equations (1) and (2) have not taken into consideration ths spatial distribution of carrier and photon in the activated region. Rigorously, they are suitable for single-mode lasers. However, if N_p and N_e are the mean light intensity of all modes and mean spatial carrier, Equations (1) and (2) can also be used to determine instantaneous characteristics of a multiple mode laser.[3,4] The results are essentially identical in the time domain of the laser.

In our analysis, τ_e = 2 ns, τ_p = 2 ps, B = 10^{-4}, A = $1/N_{th}$ ($\tau_p/1-\xi$), ξ = 0.3. N_{th} is the threshold carrier concentration. These values are in agreement with the typical data in the literature. Therefore, the results have general significance and can be used for comparison purposes.

Equations (1) and (2) can be solved using a variable-step-length Runge-Kutta method. Figure 5 shows a set of solutions. It shows that the laser gradually changes from symmetric to asymmetric and finally to sub-harmonic pulse oscillation. When the radio frequency is high, the laser outputs symmetric pulses, as shown in Figure 5(a). Figure 5(a) also displays wave forms of the radio-frequency current and carrier current. When I_{RF} drops to 2.9 I_{th} (I_{th} is the threshold current), the laser output is asymmetric, as shown in Figure 5(b). The figure only shows the light pulse (i.e., N_p) and current variations in two cycles. N_e and N_p vary with time at a period of 2T and T is the period of the radio-frequency current. To decrease the radio-frequency current further would cause the carriers to drop so that each current pulse cannot sustain a light-pulse oscillation. In this case, the laser is in sub-harmonic pulse oscillation, as shown in Figure 5(c). Thus, the numerical solution to Equations (1) and (2) can totally explain the experimental results described in the previous section.

Figure 5(c) also includes a very-low-intensity light pulse N_{p2}. In reality, $N_{p2} << N_{p1}$, and N_{p2} may be omitted. At this moment, N_{p2} may be buried by the spontaneous radiation noise. In this case, $N_{p2} \neq 0$ is related to $B \neq 0$ in Equation (2). When I_{RF} decreases, N_{p2} may decline further.

The normal dependence of the asymmetric laser pulse oscillation area upon I_{RF} is shown in Figure 6(a). N_{p1} and N_{p2} represent the amplitudes of two series of pulses of different intensity. If $N_{p1} = N_{p2}$, it is the normal symmetric pulse. From Figure 6(a) one can see that when the radio-frequency current is sufficiently high, the laser pulse oscillation is symmetric. Asymmetric pulse oscillation only occurs when I_{RF} is low. Although symmetric pulse oscillation may occur when I_{RF} is very small, as shown in Figure 6(a), N_p is also very small in this case and it is almost the same as spontaneous radiation noise. The three curves in Figure 6(a) can satisfy $N_{p1} >> N_{p2}$ in some areas, and N_{p2} can be neglected; the laser is in sub-harmonic oscillation. As described before, N_{p2} cannot be displayed on an oscilloscope; its magnitude is below the noise level.

The effect of the dc bias current I_{DC} on the asymmetric oscillation area is similar to that of radio-frequency current I_{RF}. The typical computed result is shown in Figure 6(b).

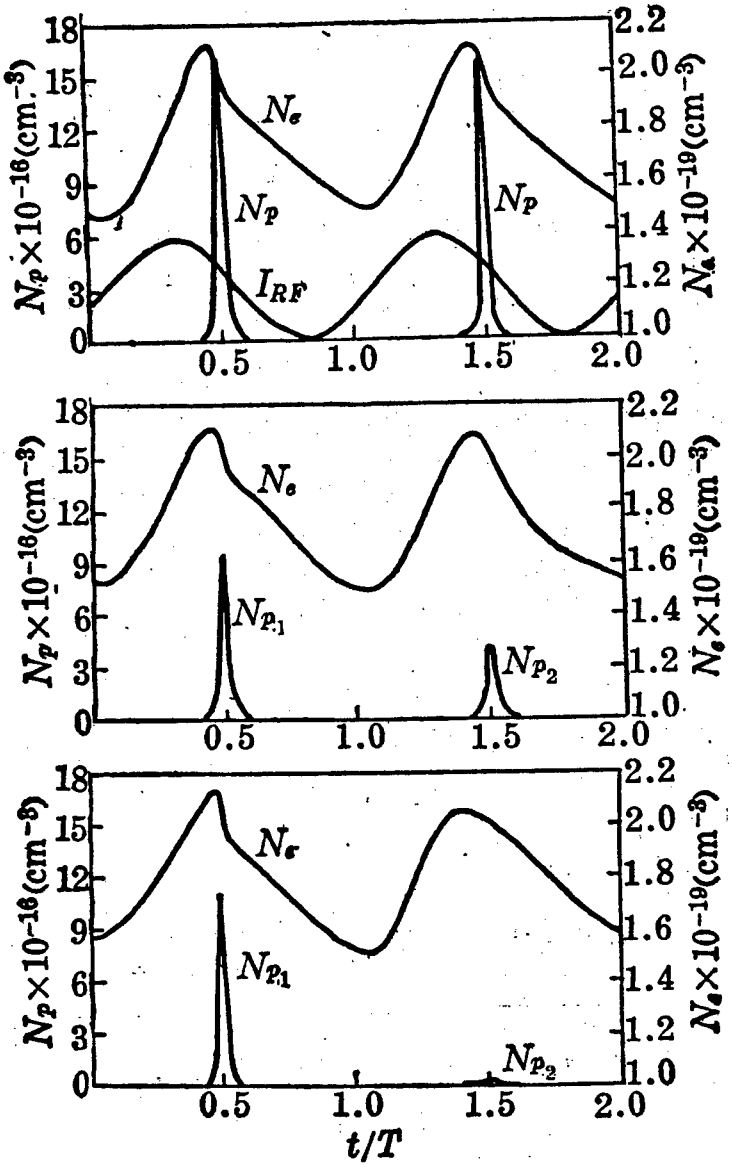

Figure 5. Effect of Radio-Frequency Current on Laser Pulse. (frequency of rf current f_m = 1 GHz, τ_e = 2 ns, τ_p = 2 ps, I_{DC} = 0.2 I_{th}); (a) I_{RF} = 3.2 I_{th}, symmetric laser pulse; (b) I_{RF} = 2.9 I_{th}, asymmetric laser pulse; (c) I_{RF} = 2.8 I_{th}, sub-harmonic laser pulse)

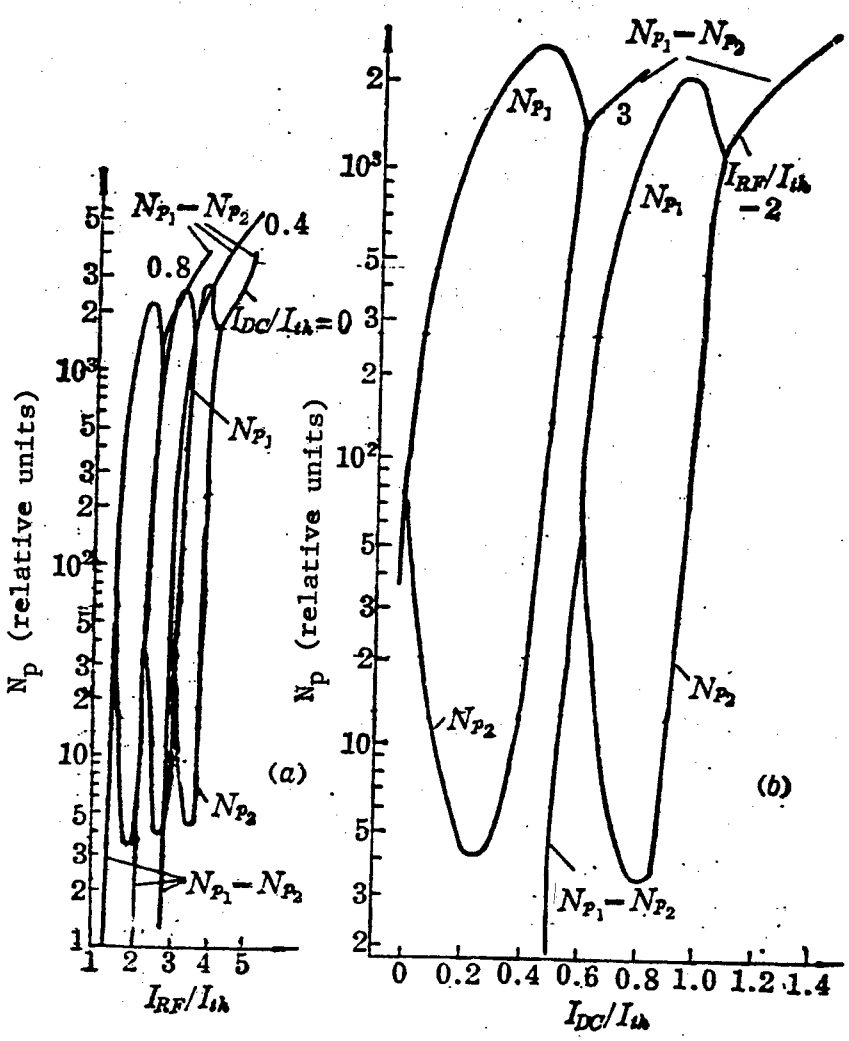

Figure 6

(a) Dependence of asymmetric pulse oscillation area on radio-frequency current I_{RF}, with variable dc bias current at $I_{DC} = 0$, $I_{DC} = 0.4\ I_{th}$, and $I_{DC} = 0.8\ I_{th}$; modulation frequency $f_m = 800$ MHz; other parameters as in Figure 5. (b) Dependence of asymmetric pulse oscillation area on dc bias current, at $I_{RF} = 2\ I_{th}$ and $I_{RF} = 3\ I_{th}$; modulation frequency $f_m = 800$ MHz, $\tau_e = 2$ ns, $\tau_p = 2$ ps.

Figure 7 shows the frequency range in which asymmetric laser pulse oscillation is produced. Asymmetric pulse oscillation can only occur when $f_1 > f_m > f_2$.

Figure 8 shows the upper and lower limit of τ_e to have asymmetric pulse oscillation. The larger τ_e is, the smaller f_1 and f_2 are. This is similar to the relation between the pulse relaxation rate of a semiconductor laser and τ_e.[4] We believe that the primary reason for asymmetric laser pulse oscillation is carrier relaxation. This can be confirmed by Figures 5 and 8.

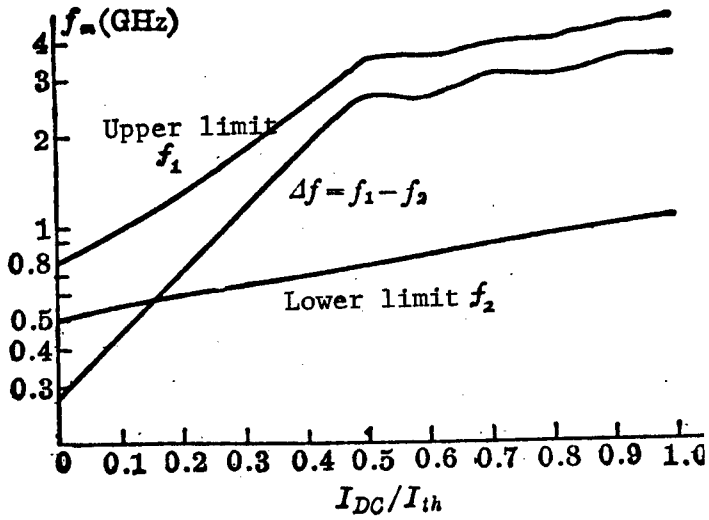

Figure 7. Modulation Frequency Range for Asymmetric Laser Pulse Oscillation; $I_R = 4\ I_{th}$, $\tau_e = 2$ ns, $\tau_p = 2$ ps.

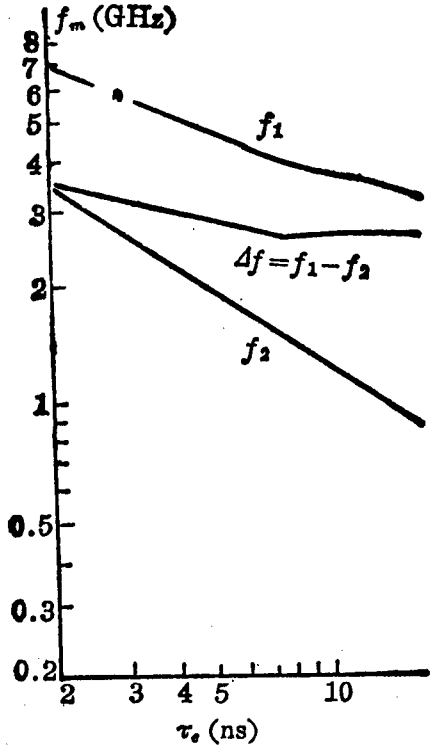

Figure 8. Dependence of Asymmetric Oscillation Frequency Area on τ_e, with $I_{DC} = 1.2\ I_{th}$ and $I_{RF} = I_{th}$

Because there is a carrier-relaxation effect, it is also possible to have a sub-harmonic pulse oscillation at one-third of the frequency, as shown in Figure 9. Figure 9 is based on numerical computation which is still to be

verified experimentally. In some instances shown in Figure 9, although $N_e > N_{th}$, there is no laser output. Otsuka also arrived at the same conclusion when he analyzed sub-harmonic pulse oscillation.

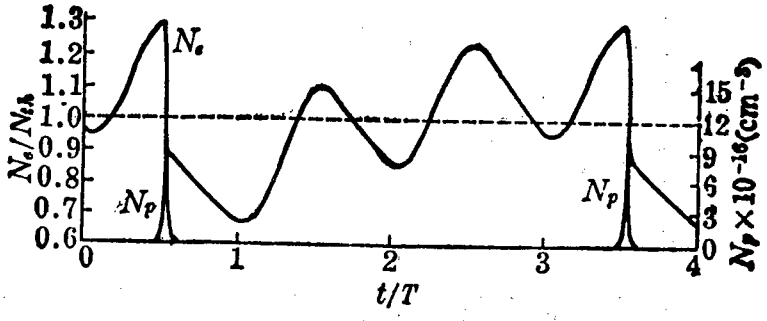

Figure 9. One-Third Frequency Sub-Harmonic Laser Pulse Oscillation; τ_e = 2 ns, τ_p = 10 ps, $AN_{th} = 5x10^{11}$, ξ = 0.8, B = 0, $I_{DC} = I_{th}$, $I_{RF} = 2\ I_{th}$, f_m = 800 MHz

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Overview of Developments in Laser Technology in China in 1988

40080143 Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 16 No 2, 20 Feb 89 pp 65-70

[Article by Zhao Meicun [6392 2734 2625], Lei Shizhan [7191 0013 3277], Huang Yongkai [7806 3057 2818], and Wang Runwen [3769 3387 2429]: "An Overview of Development of Laser Science and Technology in China in 1988"]

[Text] The unique point of the development of laser technology in China in 1988 is acceleration in the commercialization of lasers. A number of practical laser devices and products are available. Laser treatment has progressed from the surface to organs. Laser cell fusion has been successfully achieved which created a new tool in bioengineering. It is more apparent that laser technology can promote economic growth.

Laser Devices

Nd:YAP Laser for Precision Measurement

The Fujian Institute of Materials Structure of the Chinese Academy of Sciences successfully developed a CW single transverse mode Nd:YAP laser with very high frequency stability. They studied the physical mechanism of the resonance cavity and the cause of frequency flutter in depth. A technique was developed not only to suppress the sharp peak due to relaxation oscillation but also to resist low frequency interference. The frequency flutter (25 kHz) is reduced to ±0.875 percent. The near linearly polarized laser output at 1.3414 μm is 5.2 W. This device has been used in the testing of single mode optical fiber and its related devices, as well as in the high precision measurement of index of refraction of biaxial crystal.

Lasers for Industrial Applications

Central China University of Science and Technology and Northern China Institute of Optoelectronics separately developed high power CW Nd:YAG lasers above 400 W. The Nd:YAG crystal was grown in a medium frequency furnace and it is 8 mm in diameter and 120 mm long. When it was pumped by a pair of 6 kW krypton lamps, the first order multi-mode laser power was 375 W. The total conversion efficiency is 3.4 percent. When two 8 mm diameter 110 mm long YAG

rods were put in series and pumped with four lamps, the laser power was 535 W, corresponding to a 2.8 percent conversion efficiency. It can be used in industrial processes such as welding, cutting and thermal treatment.

The coaxial gas recirculating $TEACO_2$ laser developed by Xidian University [formerly Northwest Institute of Telecommunications Engineering] has a peak power of 1.7 MW, repetition frequency of 26 Hz, and pulse width of 50 ns. The device employs coaxial gas flow and UV pre-ionization to keep the gas flow uniform and to allow the laser to operate smoothly. In addition, it has a glass to metal seal structure and uses a magnetically driven centrifugal fan so that the useful life is 10^6 times per filling. It is already in production. There is a wide range of potential applications in range finding, medicine and chemistry.

Shanghai Institute of Optics and Fine Mechanics and Beijing Institute of Electronics of the Chinese Academy of Sciences separately developed a 20 W copper vapor laser. The laser efficiency is approximately 6 percent. The beam diameter is approximately 30 mm, pulse width 20-35 ns, operating frequency 6-10 kHz, and beam divergence angle 10 mrad. The useful life is greater than 150 hours per filling. It is already being produced in small quantity.

Laser Performance Improved

Shanghai Institute of Optics and Fine Mechanics of the Chinese Academy of Sciences built a GW level high power CO_2 laser system which provides an experimental tool in the 10.6 μm band for basic research in physics, optics, laser chemistry and materials science. The system consists of a hybrid CO_2 laser oscillator, a shutter, a triple stage $TEACO_2$ pre-amplifier, a double stage $TEACO_2$ pre-amplifier, a large aperture $TEACO_2$ laser and an electron beam controlled CO_2 laser amplifier. The maximum laser pulse energy is 12.9 J and the maximum pulse power is 3.2 GW. The average power is 2.4 GW and the laser pulse width is less than 4 ns.

The physics department of Northwestern Polytechnical University developed a secondary plasma tube forming technique to make discharge tubes of specific cavity parameters based on the resonance requirements. A 1.2 m He-Ne laser was made which could output 66 mW (632.8 nm) of single transverse mode laser beam. The power flutter of the laser is less than 1.3 percent per hour. The divergence angle is approximately 0.27 mrad and the life time is greater than 5 years.

Since China developed a He-Ne laser that has six simultaneous spectral lines in 1987, Beijing University successfully developed a multi-line He-Ne laser which includes green light. The output intensities at 640.1, 632.8, 611.8, 604.6, 593.9 and 543.3 nm can be adjusted by varying the cavity structure. The output power of a 1.2 m long and 1 m gain area device could reach as high as 600 μW at the green line, 13.5 mW at 632.8 nm, and 1.6 mW at 593.9 nm. In addition, a new laser line at 652.5 nm was observed. It is independent of the spontaneous line of neon and may be related to Raman scattering in the cavity.

New Lasers

At Zhejiang University β-BaB_2O_4 crystal was used as a non-linear medium to obtain parametric oscillation at 0.83-0.89 μm, 1.63-1.73 μm (single resonance) and 0.97-1.18 μm (double resonance). The thresholds for resonance were 30-34 MW/cm^2 and 27-35 MW/cm^2, respectively. The maximum energy output values are 0.2 mJ and 1 mJ, respectively. The pulse widths of the pumping light and the oscillation are 7 ns and 5 ns, respectively. Angular tuning was used.

Harbin Polytechnical University developed a wide band tunable diatomic molecular sulfur laser. There are 8 laser bands between 430-520 nm and 6 laser bands between 330-390 nm. The energy output of the entire spectrum is 3 mJ and the efficiency is 2.5 percent. The pulse width is 50 ns. The life of the device is more than 3 years. It can be used in underwater communications if the energy of the laser can be increased.

Shanghai Institute of Optics and Fine Mechanics of the Chinese Academy of Sciences introduced the Model EDL-851 excimer laser pumped dye laser. The cavity of this device has a beam expanding prism and a frequency tuning grating. It consists of a one stage oscillation and two stage amplification. The same pool of dye is shared for oscillation and pre-amplification. The pool has a special guide plate to allow the laser to operate repeatedly at high frequency (8 kHz). The laser beam is bounced back to the grating once before output to compress the radiation base to 10^{-3}. The tunable range of the laser is 330-900 nm, the width of the spectral line is 0.005-0.010 nm (F-P thickness 5 mm), pulse width is 4-25 ns, beam divergence angle is 0.5-1.0 mrad, and laser efficiency is 10 percent. The laser can also be used to pump Nd:YAG, N_2 and Cu laser. This product is already available.

Beijing Institute of Semiconductors of the Chinese Academy of Sciences developed a GaAs/GaAlAs pnpn dynatron laser. The inflection voltage is 10-20 V, the maintenance current is 10-100 mA and the maintenance current is 1.4 V. The threshold current density is (2.5-5) x 10^3 A/cm^2. The laser power is several hundred mW-1 W at room temperature. The life is several thousand hours. It integrates lasing, reception, amplification, optical bistability, optical switch and electrical switch together. It has a bright prospect in optical information processing, optical storage, optical shaping, and optical data processing. They also successfully developed a homogeneous phase semiconductor laser. At -3 db the phase homogeneity is less than 1 cm. The threshold current of the device is 50-100 mA and the laser wavelength is 820-860 nm. The power output is 2-20 mW and the external quantum efficiency is 20-50 percent. The maximum operating temperature is 50°C and the useful life is over 5,000 hours. It can be coupled to an optical fiber as well. This device can be used in high precision range finding between 2-5 km.

Xidian University developed a high repetition rate ultra-short pulse semiconductor laser by direct modulation. It resulted in the laser output at 0.83 μm with a 1 GHz repetition frequency, 50 ps or less pulse width, and 3 mW or higher average power. A $LiIO_3$ frequency doubler was designed to achieve frequency doubling of a DH GaAlAs semiconductor laser for the first

time. A quadratic harmonic autocorrelation method was used to measure the pulse width of this semiconductor laser with a resolution of equal to or less than 1 ps. Shanghai Institute of Optics and Fine Mechanics developed and manufactured a small number of a short pulse GaAlAs/GaAs double heterojunction laser. It can operate in the gain switch state. The optimal operating parameters could reach 700 mW peak power, 26 ps optical pulse width, and 100 MHz repetition frequency. Its pulse characteristics are superior to those of similar Japanese products (HL7802E, LT022Mc).

Laser Materials and Elements

New Non-Linear Crystals

The new high efficiency laser frequency doubling crystal KTP developed by the crystal institute of Shangdong University is made available. The crystal growth system is stable and the growth apparatus is unique. The yield is over 80 percent. The crystal transmits a wide frequency band (0.35-4.5 μm) of light. The dimensions of the frequency doubler are (1-20) x (1-20) x (1-10) mm^3. The frequency doubling efficiency is under 70 percent and the damage threshold is over 750 MW/cm^2. It is an ideal frequency doubling material. In addition, it can be used to make parametric oscillators and laser bistable devices. The university also developed a multi-function neodymium yttrium aluminum tetra-borate (NYAB) crystal. For the first time, it was possible to realize automatic frequency doubling from 1.06 μm to 0.53 μm with NYAB crystal. The size of transparent crystals grown is more than 1 cm^3 and its pumping threshold is less than 2 mJ. The green light output is 5 mJ, the peak power is 0.5 MW, and the efficiency is over 12 percent. It can be used to make miniature lasers.

Fujian Institute of Material Structure of the Chinese Academy of Sciences developed a new non-linear optical crystal, i.e., lithium triborate (LiB_3O_5, Pnaz space group, biaxial crystal). The absorption cutoff wavelength is 160 nm. The half width of the tunable angle is 95 mrad (vertical use) and 25 mrad (non-vertical use). The laser damage threshold is as high as 24 GW/cm^2 (0.1 ns, 1.064 μm). The effective frequency doubling coefficient is three times that of KDP crystal. It can be used to double the frequency of a high power Nd:YAG laser two to three times and can also be used to make wave guide harmonic devices.

The Institute of Artificial Crystals of the Chinese Building Materials Bureau spent nearly 10 years to develop a series of procedures to overcome problems such as crystal coloration and crystal cracking and to determine the pattern of poly-domain growth in order to grow a large size ferroelectric non-linear potassium niobate (KN) crystal. The transmission band is 0.35-5 μm. The poly-domain size is 45 x 42 x 13 mm^3 and the mono-domain size is 34 x 10 x 8 mm^3. The relative change in index of refraction is 2.8×10^{-5} cm^{-1}. The crystal has a high non-linear quality factor and low frequency doubling threshold. A few milliwatts of power input can produce a quadratic harmonic wave. This is the only material that can double the frequency of a semiconductor laser. Its electro-optical quality factor is high. In electro-optical modulation, the half wave voltage is only 16 volts. Furthermore,

the response to index refraction change is fast (2 ms). Therefore, it has a wide range of applications in high technology areas such as frequency doubling, parametric oscillation and electro-optical modulation. It is already available commercially in the United States, Japan and West Germany in 1987.

Multi-Band Laser Crystals

Shanghai Institute of Optics and Fine Mechanics successfully developed the Er:YAG crystal that has 11 laser oscillation wavelengths from ultraviolet to 3 μm. It is a high concentration self-activating laser crystal. With an uncoated 6 mm diameter 95 mm long (111) rod at 50 percent Er^{3+} and pumped by two lamps, laser at 2.938 μm was obtained. Because 1.6-1.7 μm laser is safe for the human eye and 2.938 μm laser interacts strongly with the hydroxyl group. This type of laser has very high potential in laser surgery and bioengineering.

High Quality Laser Polarization Prism

Since the laser laboratory at Qufu Normal University developed an adjustable beam splitting angle prism which received a national invention award and a silver medal at the 14th international invention exhibition at Geneva, they have successfully developed the Model LGP-6 Max Planck-Hess prism, the LGP-8 ultra-high transmission polarizer and the LSP-9 parallel beam splitting polarizer. The transmission ratios are 0.86, 0.99 and 0.91, respectively. The attenuation ratio is 10^{-5} for all of them. The wave front distortion is 1/8 λ. The distinct advantage of these devices is their high resistance to laser damage, approximately 50 W/cm^2 (continuous) or 300 W/cm^2 (pulse).

Basic Research

The frequency doubled output of a single mode stable frequency CW YAG ring laser (several scores of mW) was used to pump a simple combination parameter oscillator at the Beijing Institute of Physics, Chinese Academy of Sciences. A 63 percent compression ratio was achieved. The parametric oscillator cavity is 100 mm long and the radius of curvature of the mirror is 50 mm. The compression ratio of the 1.064 μm laser light generated by the oscillator was measured with a balanced null beat detector. The result indicated that the compressed state is a very small state which cannot be accurately measured. It is an example of the Heisenberg uncertainty principle. In order to demonstrate the prospect of the compressed state, they used the compressed light in the phase modulation of the Mach-Zehnder interferometer and in amplitude modulation which improved the signal to noise ratios by 3 dB and 2.5 dB, respectively, compared to the signal to noise ratios with maximum scattered noise.

Chengdu Institute of Telecommunications Engineering successfully developed an 8 mm quasi-optical energy injector based on its research work on quasi-optical open cavity. It provides a new tool for free electron laser experiment. The working frequency of the injector is 34.36 GHz. The mode of circular wave guide is H_{11} in the interaction region. The overall

injection efficiency is greater than 40 percent. The injector is vacuum sealed. The input wave guide is sealed with quartz windows. Its major advantages include: good unidirectional transmission, single injection mode, and excellent monochromaticity which lower the requirement on the monochromaticity of the light source. It has been delivered to other institutions for use and has met the needs in free electron laser amplification experiments.

The optoelectronic institute at Harbin Polytechnical University achieved laser oscillation between the first and third triplet states ($1^3\Sigma_g^+ - 1^3\Sigma_\mu^+$) of diatomic sodium by using a 337.0-342.0 nm dye laser as the excitation source. The single path gain was enhanced by a factor of 100-1,000. The divergence angle is 6 mrad and the laser oscillation threshold is 80 μJ. The spectral line width is approximately 2/3. Furthermore, an apparent harmonic cavity effect was observed. They also used a ruby laser to excite CH_4. When the laser energy increased to 1.4 J and the power density was 3 GW/cm^2, not only the S_1 and AS_1 spectra of the first basic vibration frequency (v_1) and the SRS spectra of v_3 and $2v_2$ of CH_4 were observed, the anti-Stoke Raman scattering line AS_1 of the second basic vibration frequency (v_2) was seen for the first time. The frequency shift is 1526 cm^{-1}.

Shanghai Jiaotong University solved the problem of calculating the optimal phase matching angle when using a biaxial crystal in non-linear optics. For the first time, the equations for a monoclinic m point group and triclinic 1 point groups d_{eff}^{I} and d_{eff}^{II} were presented. Results of 16 sum frequency and double frequency biaxial crystals and 8 biaxial crystal optical parametric oscillation were published and experimentally confirmed. The computation method and results were provided to several other units.

Super-radiation is potentially an attractive means to achieve a high intensity, narrow width coherent X-ray laser. The quantum noise is lower in compression light than that in vacuum fluctuation. It has a wide range of applications in the detection of ultra-weak signals and in optical communications. Based on the non-linear oscillation equation of super-radiation, the physics department of Northwestern University proved that triggered super-radiation might induce a compression light pulse. Thus, it is feasible to achieve X-ray compression laser pulse. Through theoretical analysis and numerical computation of the variance of the radiation field, a new theory that anti-triggered super-radiation can also induce compression light pulse was derived. In theory, it predicts an even simpler and more feasible way to achieve X-ray compression pulse laser.

An open laboratory for super fast laser spectroscopy was built at Zhongshan University. The laboratory is equipped with mode-locked laser, dye laser, excimer laser and passive mode-locked YAG laser, as well as advanced instruments such as fringe camera, ultraviolet spectrophotometer, and laser Raman spectrometer. It will be involved in the study of the principles, methods and techniques in the generation and measurement of ultra-short laser pulses, in the study of high time resolution laser spectroscopy, in the exploration and application of non-linear interaction between ultra-short laser pulse and matters, in the study of super fast energy and charge transfer processes

in photophysics, photochemistry and photobiology, in the study of collision, excitation and relaxation of atom and molecules, in the study of the instantaneous spectroscopy of complicated molecules, biological macromolecules and condensed state systems, and in the study of coherent radiation mechanisms and instantaneous coherent optical effects.

Shanghai Institute of Optics and Fine Mechanics of the Chinese Academy of Sciences and Shanghai Institute of Laser Technology completed a study on the strategy of laser development in China. Based on the worldwide market situation, development trend and existing technology base in China, it is proposed that China should first accelerate the commercialization of laser research accomplishments, encourage laser technology breakthroughs, and organize major laser tracking projects. In addition, basic research and training of technical staff must also be stressed. The report also indicates that efforts should be focused on the laser processing and optical information industry, including laser thermal treatment, cutting and welding, and optical printing and storage. The next area is energy related laser technology such as laser induced uranium isotope separation, laser nuclear fusion, and high energy military lasers. It also points out that with tighter management, additional funding, emphasis on basic research, and combining Western and Chinese medicine, medical application of laser can grow rapidly in a unique manner.

Laser Applications

Application of Laser Technology in Electronics Industry

Shanghai Institute of Optics and Fine Mechanics developed the Model LTT-1 laser thermistor resistance trimming machine which uses a 4.5-16.7 mJ, 30 ns wide Nd:YAG laser with a repetition frequency of either 1, 2, or 5 pps to trim the resistance value of thermistors. The resistance trimming beam is 30 μm in diameter and the resistance trimming accuracy is ±0.12 percent. The platform travels in a 60 x 60 mm area. It is not only easy to operate and reliable but also drastically increases the accuracy of resistance trimming to improve its interchangeability.

Bridge Inspection With Laser

The model BJQN-1 laser bridge perturbation detector was successfully developed by the Beijing Institute of Optoelectronics. The instrument uses a 3.5 mW He-Ne laser with a 230 mm discharge tube. The expanded laser beam is aimed at a conical prism on the bridge. The reflected light forms an image on an array of CCD diodes. When the train travels across the bridge, the image moves up and down due to vibration. This can be translated into dynamic bridge perturbation data by a microcomputer. Automatic compensation and error correction can also be made by the microcomputer to reduce the effect of air vibration on accuracy to below 0.1 mm. The overall accuracy of the instrument is ±0.2 mm. The range is 10-100 m and the area is 0-45 mm.

Laser Micro-Sampling

Anhui Institute of Optics and Fine Mechanics of the Chinese Academy of Sciences developed the Model JC-1 laser micro-sampler with a ruby laser ($E_p > 0.7J$, $\Delta E/E < \pm 10$ percent). The sampling amount is 10^{-8} g. The diameter of the melted sampling hole is 10-300 μm. It is capable of taking samples non-destructively from various materials such as metals, ores, crystals and semiconductors. The sample can be quantitatively or qualitatively analyzed with a conventional spectrometer.

The HSC-900 Laser Holographic and Scattered Spot Analyzer

This analyzer was constructed at Xian Jiaotong University. It can perform laser holographic and scattered spot photography. It has a dual holographic or scattered spot camera head that can operate simultaneously. It is fully automatic in exposure and processing. A computer is used to automatically process and analyze holograms and interference patterns. It is essentially a portable holographic and scattered spot camera with an adjustable stroboscope. There is a wide range of applications in engineering mechanics, machine building, and aerospace industry.

Kilowatt CO_2 Laser for Cylinder Hardening Production Line

Shanghai Institute of Optics and Fine Mechanics of the Chinese Academy of Sciences developed a kW CO_2 laser and signed a technical cooperation agreement with Changchun First Automobile Plant to build a production line for hardening engine cylinders with laser. The institute will provide 8 sets of 1800 W CO_2 lasers together with the associated optical guide and electrical control systems. This new technology improves the erosion resistance of the cylinder and raises the useful operating life from under 100,000 kilometers to over 200,000 kilometers which significantly conserves precious materials.

Breakthroughs in Agricultural Applications

Progress has been made in agricultural applications with laser. The new rice species "Xiangji 80-32" on the average yielded 450 kg per mu. "Qinmai No 6," the laser treated wheat, has good resistance against diseases, is highly adaptable, and has a high and stable yield. The mutation product "815031" of early maturing wheat can be used to breed into different products. Several variations from the L_2 and L_3 stages during the split of the wheat pollen have been obtained. We have several thousands of plants with 50-60 g grains. In addition, far infrared laser was used to produce the F_2 series of rice. It was found that there are changes in the esterase isoenzyme band and cell differentiation is enhanced. Far infrared laser can also increase the seedling yield for wheat and soybean. The final yield is also higher than that of the control group. It raises the esterase activity in wheat.

A great deal of progress has been made in laser animal breeding. Shangdong Institute of Oceanography successfully achieved laser induced cell fusion. The wavelength of the laser is tunable from 530-590 nm, the peak power

density is 10^8 W/cm^2, and the dimension of laser beam is nm. Some 120 pairs of fertilized loach eggs were irradiated by laser. They were irradiated at a precise position perpendicular to the upper edge of the protoplasmic membrane in the fusion area. Thirty-seven fused eggs were obtained. These eggs have developed into fish normally without incident, demonstrating the feasibility of laser fusion technique in animal breeding. Its obvious advantages include that it is non-toxic, causes no damage to cells and has high survival rate after fusion. The Inner Mongolia Institute of Agriculture and Animal Husbandry used a laser to irradiate milk goat sperm and found improvement in the activity and quality of the sperm. They did not see any abnormal baby goats and did not notice any significant difference. In addition, a laser was used to irradiate sheep sperm in-vitro. It was found that GOT was activated. Furthermore, a small dose of laser has a temporary suppression effect on enzyme.

Advances in Laser Medicine

In the field of laser medicine, in addition to the treatment of diseases on the surface and in cosmetic surgery, we have successfully developed the 8 W light knife for the removal of the cervix and hemorrhoids and the deep breathing treatment machine for soft tissue injury. In addition, laser systems capable of treating internal organ diseases are available. For instance, Beijing Industrial Institute, Beijing Institute of Optoelectronics and Shanghai Huangpu Hospital jointly developed a laser fiber optical gastroscope and stone crushing system. The system uses a Nd:YAG laser. The laser energy output at the fiber end is 0-100 mJ. The power output fluctuation is less than 8 percent and the pulse is greater than 0.2 ms. The diameter of the quartz fiber is 400-500 μm and its transmittance is 80 percent with respect to 1.06 μm light. The gastroscope carries a charge (2 mm diameter, 1.2 cm long) at the tip of the fiber. It is detonated by laser to produce an intense impact wave to crush the stones. Crushed stones are then removed by the gastroscope. Stomach stones as large as 8 x 10 x 6 cm^3 have been successfully crushed. The system can also be used to treat stones in the bladder, urinary tract, and gall bladder. It is compact, easy to operate, safe, reliable and quiet, and can relieve the pain of the patient. Anhui Institute of Optics and Fine Mechanics of the Chinese Academy of Sciences used excimer laser, Nd:YAG laser and CO_2 laser to perform a series of experiments in laser blood vessel forming and myocardium ablation and obtained very important results. These are important clinical data on the treatment of cardiovascular diseases with laser.

The authors wish to express gratitude to individuals and organizations providing information on the development of laser technology.

Ion Channeling Analysis of $In_{0.25}Ga_{0.75}As$/GaAs Strained Heterojunction

40090051a Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 10 No 1, Jan 89 pp 12-17

[English abstract of article by Yin Shiduan [3009 1102 4551] et al. of the Institute of Semiconductors, Chinese Academy of Sciences, Beijing; and Liu Jiarui [0491 1367 3843] and Zhu Peiran [2612 3099 3544] of the Institute of Physics, Chinese Academy of Sciences, Beijing]

[Text] The structure of $In_{0.25}Ga_{0.75}As$/GaAs strained heterojunction is investigated by means of lithium ion-beam analysis. Channeling and angular scan measurements suggest that lattice strain occurs in the interface because of the lattice mismatch between the lattice constants of $In_{0.25}Ga_{0.75}As$ and GaAs. There is an expansion and contraction of the equilibrium lattice constant of about 0.04 Å in the interface, and these stresses cause tetragonal distortions of 0.9°. Abnormally high dechanneling is observed due to the presence of this lattice strain. Lattice defects in the epitaxial layer also give rise to a significant dechanneling.

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Study of Positron Annihilation Characteristics in SI-,n-GaAs

40090051b Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 10 No 1, Jan 89 pp 18-23

[English abstract of article by Wu Fengmei [0702 7685 5019] et al. of the Department of Physics, Nanjing University, Nanjing; and Zhang Dehong [1728 1795 1347] of the Nanjing Electronic Device Institute, Nanjing]

[Text] Using the positron annihilation technique, the annealing behavior and the effects of the epitaxial process on SI-GaAs and n-GaAs:Te have been studied. Results show that the mean lifetime τ_M, the long lifetime τ_2, and the bulk lifetime τ_b of GaAs depend upon doping, and that changes in τ_2 are related to both Ga-vacancy and multi-Ga-vacancy. After the epitaxial process, the decrease in the values of I_2 and the increase in the values of τ_2 are obvious. The influence of electron and neutron irradiation is also discussed.

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Study of Lattice Mismatch in GaAs Epilayers Grown on Si GaAs:In Substrate

40090051c Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 10 No 2, Feb 89 pp 81-85

[English abstract of article by Yang Baohua [2799 0202 5478] et al. of the Institute of Semiconductors, Chinese Academy of Sciences, Beijing]

[Text] The LPE [liquid phase epitaxy] and VPE [vapor phase epitaxy] growth of GaAs on SI GaAs:In (001) substrate is reported. The lattice mismatch between epilayer and substrate has been studied by double-crystal X-ray diffraction and optical photographic methods. Results show that when the In composition X in the substrate is less than 0.004, no misfit dislocation is generated during growth, the misfit strain induced by the lattice mismatch is accommodated mainly by elastic deformation, and good surface morphology can be obtained. When the In composition X exceeds 0.006, misfit dislocations are found to be generated, the relaxation of the misfit strain is caused mainly by misfit dislocations, and a "cross-hatch" pattern appeared along the [110] and [$\bar{1}$10] directions in the LPE layer surface. The critical composition X_c of In for plastic deformation of the epilayer is between 0.004 and 0.006.

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Measurement of One-Dimensional MBE $[(Al_xGa_{1-x}As)_1(GaAs)_m]_n$/GaAs(001) Superlattice Structure Parameters by X-Ray Double-Crystal Diffractometry

40090051d Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 10 No 2, Feb 89 pp 86-92

[English abstract of article by Jiang Li [1203 0500] and Wu Cangsheng [0702 5547 3932] of the Institute of High-Energy Physics, CAS; and Wang Yutian [3769 3768 3944] and Gao Weibin [7559 4850 6333] of the Institute of Semiconductors, CAS]

[Text] Based on the step model of superlattice construction, the relative intensity of the X-ray diffraction peaks in the superlattice are derived. The rocking curves of a one-dimensional MBE [molecular beam epitaxy] $[(Al_xGa_{1-x}As)_1(GaAs)_m]_n$/GaAs(001) superlattice are measured by X-ray double-crystal diffractometry. The superlattice period D, $Al_xGa_{1-x}As$ layer thickness L_b, Al concentration x, and GaAs layer thickness L_x are obtained from the angular separations $\Delta\theta$ and relative intensities between these satellite peaks, located around the main reflection peak of the superlattice rocking curves.

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Quantum Transport Properties of Two-Dimensional Holes in GaAs/P-$Al_xGa_{1-x}As$ Heterostructures

40090051e Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 10 No 2, Feb 89 pp 100-107

[English abstract of article by Zhou Haiping [0719 3189 1627] et al. of the Institute of Semiconductors, CAS, Beijing]

[Text] The influences of the complexities in subband structures of two-dimensional holes on both integral quantum Hall effect (IQHE) and anomalous positive magnetoresistance (APMR) are studied in GaAs/P-$Al_xGa_{1-x}As$ heterostructures. A model fitting with the measured data of APMR shows that the APMR in a weak magnetic field is not simply due to classical magnetoresistance in a two-carrier conducting system, but to its deep quantum origins in the context of particle-particle interaction.

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Optimum Design Geometry Dimensions of n^+-GaAs/SI-GaAs Beam-Lead Schottky Barrier Mixer Diode

40090051f Beijing BANDAOTI XUEBAO [CHINESE JOURNAL OF SEMICONDUCTORS] in Chinese Vol 10 No 2, Feb 89 pp 108-116

[English abstract of article by Zheng Dong [6774 2639] et al. of the Institute of Semiconductors, CAS]

[Text] Optimum geometrical dimensions are derived for an [n^+-GaAs/SI-GaAs] beam-lead Schottky barrier mixer diode by using CAD [computer aided design] technology based on Pucel models of planar capacitor and Berger models of planar resistor. The total capacitance and total resistance of the diode need to be minimum in order to increase the cutoff frequency and improve the noise characteristics for a certain condition. A typical value of the DSB [double sideband] noise figure of the mixer diode is 4.8dB at 35GHz, which accords with the prediction.

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High-Temperature Superconductor Research at Advanced World Levels

40080147a Beijing KEJI RIBAO in Chinese 24 Feb 89 p 1

[Article by Xin Wen [6580 2429]: "China's Superconductor Research Attained World Stature"]

[Text] According to information released by the Superconductor Technology Joint Research and Development Center, thin films of yttrium barium copper oxide have been successfully produced on strontium titanate substrate using a radio frequency magnetically controlled sputtering method. The critical current density at 77.3K is a state-of-the-art 1.34×10^6 A/cm^2. This research result was obtained by Scientist Li Lin [2621 2651] and Associate Scientist Zhao Boru [6392 0130 0320], both of the Institute of Physics, Chinese Academy of Sciences, in their study of the metal oxide superconductor thin film preparation process and its superconductivity properties. Their research project, entitled "Basic Study of Thin Film Materials and Their Applications," is one of the major basic research programs sponsored by the National Natural Science Foundation. This is a new achievement in the past year after researchers obtained a T_c of 90.5K in yttrium barium copper oxide thin films on strontium titanate substrate.

The development of thin film materials is directly related to signal processing, microelectronics technology and computer science. Only a few laboratories in the United States, Japan, and Federal Republic of Germany have achieved 10^6 A/cm^2 order of current density in high T_c superconducting thin films. This current density refers to the maximum current flowing through a square centimeter; the greater this current density, the closer it is to practical applications. China's high quality superconducting thin film has contributed toward practical application of high T_c materials and enhanced China's competitiveness on the international market.

It was understood that the Institute of Electronics of the Chinese Academy of Sciences used a resistive heating method in preparing the yttrium barium copper oxide superconducting thin films. The zero-resistance temperature has reached 88K and the critical current density at 82K was 1700 A.cm^2. The material has already been used in the development of infrared detectors.

High Efficiency Ground Receiving Antenna for Satellite Application

40080128a Beijing DIANZI SHICHANG [ELECTRONICS MARKET] in Chinese 5 Jan 89 p 2

[Article by Zhang Lirong [1728 4539 2837]]

[Text] The Jiangdu County [Jiangsu Province] No 2 Stamping Factory recently succeeded in building a parabolic ground receiving antenna for satellite applications. This is a high-gain, low-sidelobe antenna designed by the Nanjing Zijin Shan Observatory of the Chinese Academy of Sciences. Two antenna models with diameters of 4.5 m and 6.1 m respectively are already in small-batch production.

This antenna can be connected with a receiver through a specially designed feed. It is primarily used in a television relay station or a closed-circuit television system to receive TV programs rebroadcast through satellites, and can also be used for microwave communications. Its operating frequency is 3.7-4.2 MHz, and it has a gain of 44-46 dB; it can be steered either electrically or manually over the range of 0° - 90° in elevation and 0° - 360° in azimuth. The parabolic surface is made of square aluminum tubes and aluminum mesh. It has many desirable features: light weight, low wind resitance, high structural strength and durability, ease of transport and adjustment, and high reliability. It can operate normally under a wind velocity of 30 m/s, and can survive a wind velocity of 50 m/s without damage. Currently, this antenna is already in service in Nanjing, Bengbu [Anhui Province], and other areas; its performance in terms of TV picture quality is excellent.

Plans for Military Communications in the Nineties

40080128b Beijing ZHONGGUO DIANZI BAO in Chinese 13 Jan 89 p 3

[Article by Yang Jinhe [2799 6855 3109] and Fang Zhiqi [2455 0037 0796]]

[Text] Since China initiated its policy of opening up and witnessed the technological revolution taking place around the world, there has been concern that China's military communications systems would face a serious challenge.

In late November of last year, the General Staff's Signal Corps Department, the General Staff's No 4 Department, the Chinese Electronics Society, and the Chinese Institute of Communications jointly sponsored the first "National Military Communications Conference" in Guangzhou. More than 100 government officials, technical specialists, and scholars participated in the conference to discuss directions and to study effective ways to develop China's military communications.

Meeting the Challenge of the New Technological Revolution.

Tong Zhipeng [4547 1807 7720], Director of the Institute of Electronic Science in the Ministry of Machine-Building & Electronics Industry: In the 1980's, unprecedented advances in microelectronics, opto-electronics, and microprocessors have had a significant impacton the development of modern communications technology. The extensive use of large-scale integrated circuits and microprocessors in the field of communications has made it possible to bring many previously unachievable technologies and equipment into reality. Since China opened its door to the outside world, we not only have access to information in the open literature, but can also import foreign technologies, purchase equipment, or even acquire entire systems directly from abroad. This new scenario represents challenges as well as opportunities. We are faced with the decision of choosing a new policy and a new direction for developing China's military communications systems, theory, equipment and technologies. Looking toward the future, there will undoubtedly be fierce competition in the areas of modernizing communications equipment, and developing jamming and anti-jamming equipment, surveillance and counter-surveillance equipment, and intercept and counter-intercept equipment. In short, military communications will play a deciding role in future warfare.

Development of Military Communications Technology Abroad Is Progressing at an Astonishing Pace.

Liu Yongjun [0491 3057 1498], Chief Engineer of the Chinese Electronics Society and Institute of Communications: In recent years, military communications technology has been advancing at a rapid pace. In strategic communications systems, long-distance telephone networks in the United States, the Soviet Union, and elsewhere are being converted to digital systems; data network information exchange is being replaced by packet exchange; new digital speech codes and digital [stored] program-controlled exchanges are being used in secure telephone networks. There are plans to combine these three networks into a military "Integrated Services Digital Network." In tactical communications systems, each branch of military service has a tactical communications system to support its own battle command. For example, the French "RITA" system and the British "Ptarmigan" system are regional communication networks which have been extensively tested in actual field combat. They have been shown to have very high standards in terms of survivability, anti-jamming capability, mobility, and security. In particular, the anti-jamming, anti-intercept, and adaptive capabilities of the microprocessor-controlled, frequency-hopping digital stations are very impressive. Advances in military communications satellites and the application of artificial intelligence in military networks have also been quite remarkable.

Practical Guidelines for Developing China's Military Communications.

Wu Zhigang [0702 1807 0474] and Zhang Wenjie [1728 2429 3381] from Research Institute 61 of the General Staff Headquarters: Today, there exists a huge gap between the state of our military communications equipment and that of developed countries. While a wired telecommunications system has been established by the Chinese military, it is still in a state of manual switching and analog communications. Our radio communications equipment is one or two generations behind other countries; in our systems, microprocessor-controlled equipment and large-capacity microwave trunk lines are not yet available, and satellite communications is still in its infant stage. During the next 15 years, we should devote our efforts to the establishment of an integrated communications system which combines telephone switching networks, data switching networks, and secure telephone networks.

Socialistic Strategy for the Initial Stage of Military Communications Reform.

Yang Qianli [2799 0578 6849], Deputy Director of the Signal Corps of the General Staff Headquarters: During the past several decades since the People's Republic came into being, a first-generation communications system has been established on the basis of the old system; but the current system has many problems that must be corrected. Specifically, we must replace old communications equipment with new units, and we must keep up with new technologies and take advantage of the products of advanced research and development. An effective way to absorb advanced technologies from abroad while maintaining normal operation of current military communications systems is to import advanced technologies on a limited scale for trial operation in a small military unit.

Institute Director Tong Zhipeng: We should organize our research into military communications equipment and technology on the basis of the following considerations: meeting combat requirements, promoting technological advancement, and deriving overall benefits. The focus of research topics should be continually adjusted according to the changing characteristics of future warfare. We should keep up with new technologies, new materials, new manufacturing procedures, and new structures used by foreign military services. Finally, we must ensure successful product development by coordinating our research efforts with manufacturing and assembly.

Yuan Banggen [5913 6721 2704], Chief of the Signal Corps Department for the Guangzhou Military Area: An important consideration in modernizing China's military communications system is to coordinate the development of military and commercial communications to satisfy both wartime and peacetime needs. For example, a communications system which is designed to support the nation's economic development during peacetime must give its highest priority to military services in case a war breaks out.

Chinese-Character Cable Teletext System

40080128c Beijing ZHONGGUO DIANZI BAO in Chinese 17 Jan 89 p 3

[Article by Li Qiongrui [2621 8825 3843]]

[Text] The Chinese-character cable teletext system developed by Institute 3 of the Ministry of Machine-Building and Electronics Industry recently passed technical certification.

The cable teletext broadcasting system is a new information-service system developed in the early 1980's. But since most systems developed abroad do not have the ability to process Chinese characters, they cannot be used directly in this country. For this reason, Institute 3 initiated an effort to apply the teletext broadcasting technique with Chinese-character codes to cable television distribution, and for the first time in this country, it has succeeded in developing a practical Chinese-character broadcasting system. By taking advantage of the text and graphics editing capabilities of Chinese-made microcomputers and the unique features of information transmission and display of existing cable television systems, it has developed a high-speed, high-efficiency, easy-to-use, and inexpensive integrated information-service system. The system has three major segments: the cable television system, the teletext program editing and broadcasting system, and the teletext receiver.

The potential users of this system include: restaurants, hotels, offices, and industrial management agencies; furthermore, this system provides the technical foundation for developing China's future teletext broadcasting network.

Multifunctional Digital Microwave Terminal

40080128d Beijing ZHONGGUO DIANZI BAO in Chinese 17 Jan 89 p 3

[Article by Zhang Daobin [1728 6670 3453]]

[Text] The multifunctional digital terminal which had been used for the first time in China's microwave transmission systems for radio broadcasting, television and communications recently passed certification in Beijing. This digital terminal was developed jointly by Institute 3 of the Ministry of Machine-Building and Electronics Industry and by the Hua Qiang Co. in Shenzhen. The terminal has been integrated with the microwave transmitter/receiver developed by Institute 54 of the ministry for implementation in the dedicated information network between the Xingtai Bureau of Mines [Hebei Province] and the Dong Pang Mine.

The multifunctional digital terminal is the digital framework of the microwave transmission system. It uses the techniques of pulse code modulation and companding in its design, and its components include the transmitting terminal, the receiving terminal, and their interfaces. Such a microwave transmission system can transmit one channel of picture images, and with the aid of the terminal, it can also transmit one channel of radio-broadcast signals (or television with audio signals), 24 channels of telephone signals and 40 kb/s of independent data within the 2048 kb/s "DS1" [transmission rate]. It significantly improves the quality of communications and reduces the relay time.

A multifunctional microwave transmission system which integrates the digital terminal with a microwave transmitter/receiver is an ideal small-scale communications system which can be used by large corporations, mining operations, oil fields, towns and villages, and remote regions for transmitting television/radio signals and other information.

New Fiber-Optic Products

40080128e Beijing ZHONGGUO DIANZI BAO in Chinese 20 Jan 89 p 3

[Article by Song Jinsheng [1345 6855 5116]]

[Text] Research Institute 23 of the Ministry of Machine-Building and Electronics Industry has developed three new fiber-optic products for both communications and non-communications applications: the GLF-1B single-mode, single-fiber optical-cable connector; the JG40-2.5-01 double-fiber tactical optical-cable connector; and a fiber-optic temperature-alarm unit.

The GLF-18 optical-cable connector has been developed as part of the designated tasks assigned by the State Commission of Science, Technology and Industry for National Defense. It is designed in accordance with both China's national standards and IEC [International Electrotechnical Commission] standards; it is compatible with the Japanese FC type single-mode connectors, and can be used for modular connections between optical terminals and cables, between optical cables, and between optical cables and other instruments. The degree of concentricity between the socket of the connector and the fiber-optic core has reached sub-micron-level precision. Based on the 55 production samples, the acceptance rate is over 90 percent, and the design requirements for insertion loss ($\leq$ 0.7 dB), repeatability ($\leq$ 0.2 dB), and interchangeability ($\leq$ 1 dB) have all been met. [Preceding item also covered in JPRS-CST-89-006, 28 Feb 89, p 91.]

The JG40-2.5-01 double-fiber tactical cable connector uses a neutral structure without the need for an adapter. The unit suffers a loss of less than 1.0 dB, and has a tensile strength $\leq$ 150 kG. Its sealed construction provides protection against water, humidity, dust and slush. Based on the experience of numerous tactical exercises, the unit has proved to be highly efficient and reliable; it can be mounted overhead, submerged in water, or buried underground. It is suitable for use in adverse environments such as on the combat field or inside mines.

The fiber-optic temperature alarm unit is a fixed-temperature warning device. Based on user requirement, the alarm unit can be designed to issue warning at a preset temperature within the range of 0° - 300°C. It can operate on either d.c. or a.c. power, and can be installed in storage rooms to protect against self-combustible materials.

Frequency-Hopping Spread-Spectrum System, Spread-Spectrum Multiple Access System Certified

40080128f Beijing ZHONGGUO DIANZI BAO in Chinese 27 Jan 89 p 3

[Article by Lin Feng [2651 6912]]

[Text] A high-speed frequency-hopping frequency synthesizer and hybrid spread-spectrum (FH/DS) synchronizer, and the VHF·DS/TH hybrid spread-spectrum multiple access communications transceiver were recently certified in Chengdu. These systems were developed by the University of Electronic Science & Technology [formerly Chengdu Institute of Telecommunications Engineering].

Frequency-hopping is an important anti-jamming measure used in modern electronic warfare. A frequency-hopping frequency synthesizer and synchronizer are key components in a frequency-hopping communications system. In such a system, the higher the frequency-hopping rate, the better the anti-jamming capability; also, the shorter the synchronization time, the sooner the system will become operational. Under the direction of Prof Hong Fuming [3163 4395 2494], this system has been developed to have a frequency-hopping rate of over 38,000 hops per second and a synchronization set-up time of less than 0.5 microsecond.

The VHF·DS/TH hybrid spread-spectrum multiple access communications transceiver is one particular type of spread-spectrum communications system. It has anti-jamming capabilities against directed jammers (J/S=18 dB), narrow-band jammers (J/S=19 dB) and wide-band jammers. The anti-jamming technique used by the transceiver, i.e., DS plus pseudo-random time-hopping, does not require additional time synchronization; it also reduces the "far-near effect" of the DS system.

This transceiver can be used not only for military mobile communications but also for commercial applications.

Feature on Noted Radar-Antenna/Radome Specialist Du Yaowei

40080131c Beijing ZHONGGUO DIANZI BAO in Chinese 10 Feb 89 p 3

[Article by Jing Deji [4842 1795 1015]]

[Text] On the 24th floor of the Beijing Color Television Center of the Central Television Station, a Chinese-made microwave-transparent wall is built around the microwave hall. The impression from the capital's technical community on this new product has been generally favorable.

Three years ago, when no one was willing to take on this project, only one scientist in Nanjing who suffered from cancer traveled to Beijing to accept the challenge. Based on the specified requirements, he quickly completed a feasibility study for this task.

Recently, this scientist and his colleagues have been devoting their efforts to the new task of developing a "variable-thickness radome for airborne radars"; they have already completed many tests and are ready to begin preliminary design. This scientist is the noted radar antenna and radome specialist of the No 14 Research Institute of the Ministry of Mechanics and Electronics, Du Yaowei [2629 5069 1919].

In a number of interviews with this reporter, Mr Du had repeatedly said: "I must do more so China's radar antenna and radome technology can advance to the level of the developed nations." He is a down-to-earth type of person and has made numerous contributions in his field.

In 1964, after graduation from the Department of Radio Physics of Beijing University, he joined the No 14 Institute and became involved in the radome design for a large radar antenna. Before his training period was over, he already took on the responsibility of "acting group leader" of the radome development group. After 5-6 years of dedicated effort on the project, the design was completed in 1972 and the world's largest fiberglass radome with honey-comb truss design appeared on China's landscape. The superior electric properties and high-quality workmanship of the radome made it possible to survive adverse environmental conditions and severe weather changes. In 1978, he received the first national science conference award for this work.

In discussing the current state of development of radar antenna and radome technologies, he said: "In recent years, many countries have been concentrating on the research of low-sidelobe and extremely-low-sidelobe radar antennas, particularly in a phased array system and a common-configuration array system. Also, attempts have been made to incorporate digital technology in antenna applications, such as the use of microprocessor control techniques in antenna beam formation. The development of low-sidelobe and digital beam formation technologies will enhance the radar's capability against jamming and ground clutter, facilitate its track-while scan operation, and improve its resolution to allow simultaneous tracking of multiple targets." During the 1970's, while he was assigned to live and work in the mountains, he still continued his scientific research activities. In an effort to solve the difficult problem of tracking multiple high-speed targets such as missiles and aircraft, he and his colleages jointly developed the new "three-in-one" antenna system, which incorporates the new technologies of narrow-band waveguide with independent sum and difference controls, crack arrays, and phase scanning. This high-efficiency, high-precision system with multiple-target tracking capability received the second-place award for scientific achievement in 1978 from the Ministry of Electronics. In addition, by using primitive computers and home-made instruments, he struggled with many difficult technical problems over a 3-year period and finally succeeded in developing an extremely-low-sidelobe crack array antenna, for which he received the first-place award for scientific achievement from Guizhou Province.

In 1981, during one of his trips to Beijing to present a technical paper, he was involved in a car accident and was hospitalized. An examination showed that he was suffering from "fusiform-cell cancer" in his nose and throat. But he was not at all conquered by the disease; while being treated in the hospital, he tried to do research on his own about the disease, and at the same time help his colleagues in solving their technical problems. In 1983, he was released from the hospital and returned to the No 14 Institute; he could not wait to participate immediately in the current project of designing a radome for a pulse doppler radar. Against the advice of his superiors, he volunteered to return to work full-time; in just 6 short months, he completed the calculations for predicting the performance of a multi-layered radome, and published more than 10 papers on the subject. One of the papers, "Performance Calculations of Multi-Layered Radomes," which contained more than 9,000 pieces of data and over 90,000 characters, presented the detailed theoretical method and procedure for designing high-performance airborne radomes. At the same time, he also solved two difficult problems in radome coating: "anti-static electricity coating" and "rain corrosion resistant coating." Compared with papers presented at the 1984 International Electromagnetic Window Conference, Du's method of calculating radome performance meets most design requirements and can be readily applied in actual radome designs.

The microwave-transparent wall at the Beijing Color Television Center is one of Du's attempts in combining radome technology and commercial communications technology. The wall can be used in satellite ground stations and microwave relay stations for receiving or transmitting television signals. Its transmissivity is as high as 90 percent, and its reflection coefficient is less

than 3 percent; it also has the property of becoming non-active within 2 seconds after the radiating source is turned off. The wall surface can withstand a pressure of 80 kg/m^2, and survive a class-10 storm. Last year, Mr Du proposed the design of a satellite TV receiving antenna for private use; this design combines a C-band antenna, a K-band antenna and a P-band antenna in a single spherical structure with foam cover. This multi-band antenna is not only attractive in appearance but also light-weight and low-cost; it can be connected to private color television sets to receive direct broadcasts of TV programs around the world.

According to statistics reported in medical journals, the chances of a nose-and-throat cancer patient to survive more than 5 years is only 26 percent. Realizing his limited time and the fact that China currently has no specialized book on radome design, this 50-year-old scientist decided to systematically collect the design experience and theories accumulated over the past two decades and compile the information into a publication before his life comes to an end.

Municipal Telephone Fiber-Optic Communications Projects Completed in Tianjin, Shanghai, and Guangzhou

40080157 Beijing ZHONGGUO DIANZI BAO in Chinese 24 Mar 89 p 1

[Article by Wang Zhendong [3076 6966 2639]]

[Summary] Financed by Japanese government loans to China, three state priority projects of the Seventh 5-Year Plan--the digital fiber-optic transformation of the municipal telephone transmission systems in Tianjin, Shanghai, and Guangzhou, the first such projects in China--have now been completed and turned over to the users. These projects, which took almost 3 years to complete, represent a total of 622,000 telephone lines opened up in the three cities.

Included in the almost 20,000 pieces of equipment installed in the systems are optoelectronic terminals, fiber-optic cables, [stored] program-controlled telephone exchanges, and testing instruments and meters. While a portion of the equipment was domestically made, the majority was imported from abroad.

Lithium Ionic Conductivity at High Hydrostatic Pressure

40090048a Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 38 No 2, Feb 89 pp 193-201

[English abstract of article by Su Fang [5685 2499], et al., of the Center of Fundamental Physics, University of Science and Technology of China, Hefei]

[Text] The ionic conductivity and activation volume of a bulk sample and compressed powder disk of the amorphous lithium ionic conductor B_2O_3-0.7Li_2O-0.7LiCl-xAl_2O_3 (x = 0.05, 0.15) in the hydrostatic pressure range of 0.0001-1.23 GPa have been investigated. The authors found that the peak of conductivity of the compressed powder disk consisted of contact conductivity and bulk conductivity. For hydrostatic pressure dependence of the ionic conductivity of the bulk sample, a preliminary microscopic explanation was obtained by studying the physical picture of the ionic transport passages. In addition, the authors observed that a decrease in content of alumina lowered the pressure of the maximum conductivity. The variation of ionic conductivity with pressure was measured after samples were heated at different temperatures or at 300°C for 4 to 20 hours. The behavior resulted from the amorphous phase separation and successive crystallization process of the two amorphous phases.

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Study of Onset of Chaos in RF-Biased Josephson Junction with Quadratic Damping

40090048b Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 38 No 2, Feb 89 pp 209-217

[English abstract of article by Xiao Wanru [5135 1238 1172] of the Division of Physics, Nanjing Architectural and Civil Engineering Institute; Yao Xixian [1202 1585 6343] of the Department of Physics, Nanjing University]

[Text] In this paper, the rf-amplitude threshold of chaos in a Josephson junction with quadratic damping is studied. Theoretical predictions based on Melnikov's method are compared with numerical simulations. It is shown that the chaotic region predicted by Melnikov's method spans only a narrow region of rf-amplitude and consists of phase-locked chaos. The experimentally observed threshold of chaos is shown to coincide with the onset of unlocked chaotic behavior at higher rf-amplitudes.

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Experimental Investigation of Properties of ECH Plasma, Hot Electron Ring

40090048c Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 38 No 2, Feb 89 pp 228-235

[English abstract of article by Guan Weishu [7070 4850 1859], et al., of Southwestern Institute of Physics, Leshan, Sichuan]

[Text] The ECRH experiment has been carried out on a simple mirror--the MM-2 device--by use of a 15 GHz high power gyrotron. The experimental results show that the preionization time will shorten rapidly after the pressure of the puffed gas has been raised. During the "C-mode" operation when the gas pressure is higher, the radial profile of plasma density exhibits a saddle shape. The gas "pressure window" for building a hot electron ring is (0.4-1.2) x 10^{-5} Torr, with a gyrotron output of about 30 kW. Simply by using a movable Langmuire probe accompanying diamagnetic measurement, it has been determined that the hot electron ring radius is 7 cm, the thickness is about 4 cm and the axial boundary of the ring extends from Z = ± 10 cm to Z = ± 20 cm when the central field is 2.95 kg. The hot electron temperature is from 140 to 170 keV. The average beta value of the hot electron ring is (4-5) percent. The radial bursts of electrons due to ring instabilities accompanied by the drops in the diamagnetic signal have also been observed.

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Probe Diagnostics of Electron Energy Distribution Function in Low Pressure RF Plasma

40090048d Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 38 No 2, Feb 89 pp 236-246

[English abstract of article by Zhu Wenhao [2612 2429 3185], et al., of the Department of Engineering Mechanics, Qinghua University]

[Text] A measuring system is developed for the diagnostics of the electron energy distribution function (EEDF) in an electrode-less low pressure rf discharge with a triple-probe system by using the probe-current modulation method. The EEDF of a nitrogen plasma in the pressure range of 10^{-3}-10^{-1} Torr is obtained. The effect of rf voltage penetrating the probe sheath on the determination of the EEDF is studied both theoretically and experimentally. A new approach used to estimate the value of rf voltage in the probe sheath and to calculate the actual EED from distorted distribution recorded during the experiments is presented, and the experimental results are corrected by using the proposed method to obtain the true EEDF. The difference between the average electron energy calculated from the corrected EED and that calculated from the V-I characteristics of the probe is slight, not greater than 5 percent, which seems to give indirect evidence in favor of the procedure used to determine the actual EED and the reliability of the measuring system.

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Thermal Stresses in Hollow Cylinder Lasers

40090048e Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 38 No 2, Feb 89 pp 247-255

[English abstract of article by Zhou Feng [0719 3536], et al., of Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences]

[Text] The hollow cylinder can provide high average power output for solid state lasers. The pumping induced temperature distribution and thermal stresses in such a glass cylinder are calculated for continuously and repetitively pumping operations. The analytical expression of maximum pumping power is given, from which the results for rod and slab lasers can be derived.

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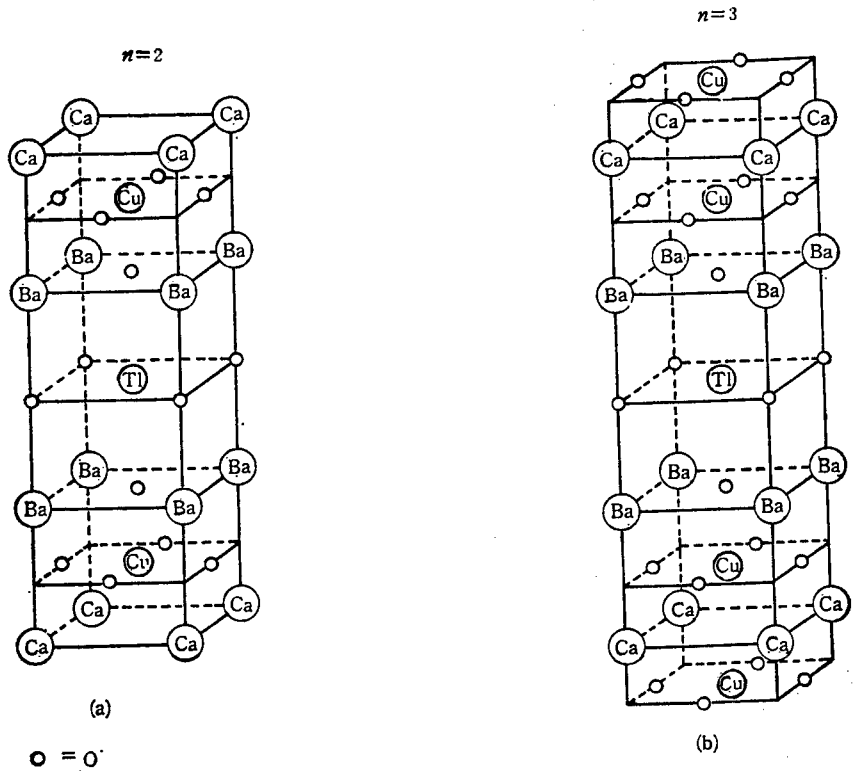
Crystal Structures, Superconductivity of New Series of Superconducting Phases

40090048f Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 38 No 2, Feb 89 pp 264-272

[English abstract of article by Liang Jingkui [2733 2417 7608], et al., of the Institute of Physics, Chinese Academy of Sciences]

[Text] The authors synthesized new superconducting phases in $TlBa_2Ca_{n-1}Cu_n-O_{2n+2.5}$ by a solid state reaction. The crystal structures of $TlBa_2CaCu_2O_{6.5}$ and $TlBa_2Ca_2Cu_3O_{8.5}$ were determined by means of the X-ray powder diffraction method. The two compounds belong to the primary lattice with the space group D^1_{4h}-P4/mmm. The lattice constants of $TlBa_2CaCu_2O_{6.5}$ are a = 3.847 Å, c = 12.73 Å. The lattice constants of $TlBa_2Ca_2Cu_3O_{8.5}$ are a = 3.847 Å, c = 15.89 Å. Each cell contains one chemical formula unit. The cations are distributed alternately at the positions (0,0,z) and 1/2, 1/2, z) along the Z axis.

$TlBa_2CaCu_2O_{6.5}$ shows zero resistance at 101.4 K. $TlBa_2Ca_2Cu_3O_{8.5}$ shows zero resistance at 112 K. The oxygen deficient pseudo-perovskite unit $Ba_2Ca_{n-1}Cu_nO_{2n+1}$ is separated by a single Tl-O layer in the crystal structure of $TlBa_2Ca_{n-1}Cu_nO_{2n+2.5}$, while the oxygen deficient pseudo-perovskite unit $Ba_2Ca_{n-1}Cu_nO_{2n}$ is separated by a Tl-O bilayer in the crystal structure of $Tl_2Ba_2Ca_{n-1}Cu_nO_{2n+2}$. At the same n value, T_c of $Tl_2Ba_2Ca_{n-1}Cu_nO_{2n+4}$ is about 10 K higher than the T_c of $TlBa_2Ca_{n-1}Cu_nO_{2n+2.5}$. This indicates that T_c depends on the number of Tl-O layers, as well as on the amount of $[CuO_5]$ and $[CuO_4]$ in the oxygen deficient pseudo-perovskite unit $Ba_2Ca_{n-1}Cu_nO_{2n}$.



(a) $TlBa_2CaCu_2O_{6.5}$

(b) $TlBa_2Ca_2Cu_3O_{8.5}$

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Weak Localization Effect in Metallic Glass $Zr_{78}Co_{22}$

40090048g Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 38 No 2, Feb 89 pp 307-312

[English abstract of article by Zhou Xianyi [0719 0341 1942], et al., of the Department of Physics, University of Science and Technology of China, Hefei]

[Text] Measurements of the magnetoresistance of the upper critical magnetic field have been made on the superconducting metallic glass $Zr_{78}Co_{22}$. The results correspond qualitatively with the weak localization theory, including spin-orbit scattering for a three-dimensional system. Quantitatively, an obvious deviation exists which originates mainly from superconducting fluctuations. In the measuring temperature range, the value of the upper critical field Mc_2 varies linearly with the temperature, and the inelastic scattering rate $\tau_i^{-1}(T) = 1.3 \times 10^{10}T^2$ is obtained, which can be attributed to the electron-phonon processes in disordered metals. This value is slightly lower than that predicted by Bergmann's theory.

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Studies of Anisotropy for Single Crystal $GdBa_2Cu_3O_{7-\delta}$

40090048h Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 38 No 2, Feb 89 pp 313-316

[English abstract of article by Fang Minghu [2455 2494 5706], et al., of the Department of Physics, University of Science and Technology of China, Hefei; Sun Dunming [1327 2415 2494], et al., of the Department of Applied Chemistry, University of Science and Technology of China, Hefei]

[Text] The authors report the experimental results of anisotropy of the normal state resistivity, transition temperature and magnetic transition in the single crystal $GdBa_2Cu_3O_{7-\delta}$. It is found that both $\rho_{//}$ and $\rho_{\perp}$ correspond very well to the Anderson-Zou relationship $\rho = A/T + BT$, except near T_c where fluctuation enhanced conductance becomes prominent. The striking difference in A, B of two directions suggests that the charge transport involves different mechanisms in the two directions and that the system exhibits remarkable two-dimensional characteristics in the normal state. The superconductivity in the c direction is weaker than that in the ab plane: $T_{ce\perp}$ is 2 K lower than $T_{ce//}$, and the ac magnetic shielding effect for the H//ab plane is only 76 percent that for the H $\perp$ ab plane.

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